REFINER
AND NATURAL GASOLINE MANUFACTURER

APRIL, 1940
Vol. 19, No. 4

A Gulf Publishing Company Publication
EDITED MONTHLY AT HOUSTON, TEXAS

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GRADY TRIPLETT
Editor

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SPECIALIZED OIL JOURNALS

Published by
THE GULF PUBLISHING COMPANY

OFFICE OF PUBLICATION
3301 Buffalo Drive, Houston, Texas

R. L. DUDLEY, *President*
A. L. BURNS, *General Manager*
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TULSA: 1304 Hunt Building, J. F. Carter, Jr., Manager.

FT. WORTH: 203 W. T. Waggoner Building, H. H. King, Manager.

Single copies 20 cents. Special issues single copies 50 cents. Domestic subscription price $1.00 a year. Canada and Foreign subscription price $2.00 a year. Entered as second class matter June 16, 1923, at the post office at Houston, Texas, under act of March 3, 1879. Advertising rates on application.

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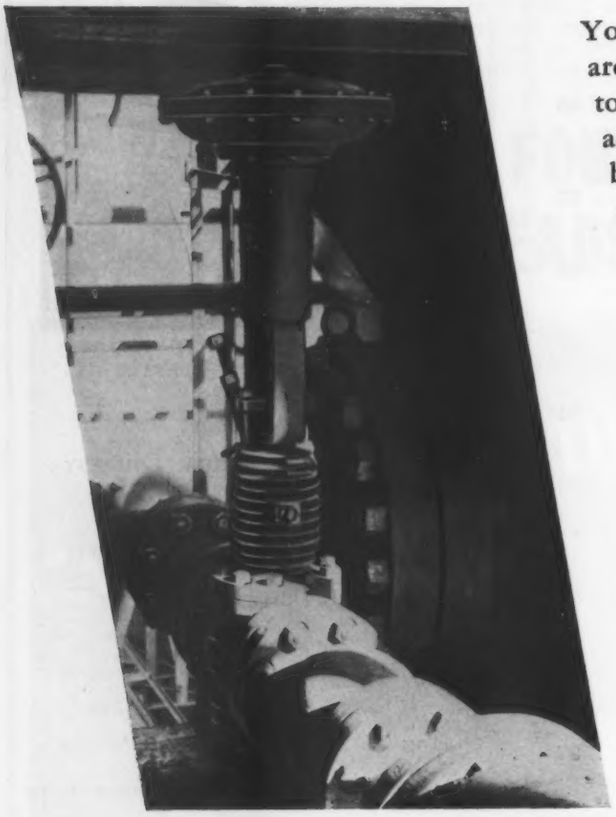
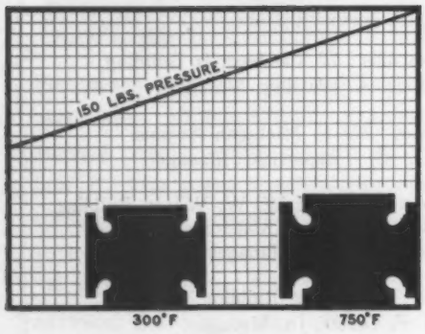
YOU NEED *More Valve* HIGH TEMPERATURE

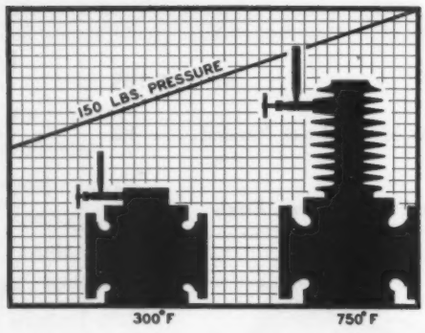


You need *More Valve* when high temperatures are involved—and adding a cooling member to protect the stuffing box is not enough. In addition you need greater strength in the valve body, greater power in the diaphragm motor and springs, and stronger stems to transmit that power.

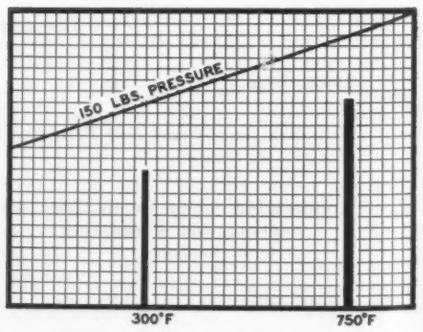
For this reason a Masoneilan high temperature valve is entirely different from a standard valve —it is built *throughout* for high temperature service. The body may have to be heavier. The valve plugs and guides are specially designed; special alloy trim may be required; valve stems are heavier to offset loss of tensile strength at high temperatures; an air-fin bonnet, with a proved efficiency far greater than is usual on other valves, is used to hold stuffing box temperature at approximately 200°F; the diaphragm area is increased at least 33% to



The pressure-temperature conditions may require using a heavier body or a body of different metallic composition.



Changing from standard to air-fin bonnet increases bonnet weight 200% or more—an indication of the mass, and hence radiating area, of the air-fin bonnet.



Longer, stronger stem is approximately 55% heavier—to offset loss of tensile strength under extreme temperature.

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VOLUME 19, No. 4 APRIL, 1940

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The Look Box

IT is encouraging to see technical progress move forward by agreement rather than stagnate through controversy. In the past research laboratories have worked toward one objective which when finally accomplished went promptly to the courts for determination of the right to use what the laboratory had provided.

Team Up and Go Ahead

All too often long litigation found the contestants still at loggerheads, the only tangible result being expense. Part of the expense could not be calculated, since loss of business had been concurrent with litigation.

Recently there have been instances of the reverse of such procedure. When patents threatened to clash, transactions took the place of litigation, leaving all patent holders in position to make a profit rather than incur expense.

Of equal value is the assurance that these process will thereby become available to the smaller refining companies whose finances do not permit research and patents. These companies, however, are ready to take advantage of technical improvements by licensing what research laboratories provide.

The industry needs more transactions and fewer treks to the court room. Good business is preferable to good law.

IN the confusion that revolves around the octane rating of gasoline, one element is clean—at last the refiner has made a motor fuel which requires the motor manufacturer to catch up. Recently it was the other way around, motors had compression ratios which made it necessary for the refiner to improve this quality in gasoline. Now gasoline can be had of octane rating higher than the automobile motor can match.

Gasoline Takes The Lead

There is something incongruous in providing motor fuel of quality higher than the average motor can efficiently use. Technical men look at that situation and protest. They ask why octane rating should be emphasized in sales promotion when the grade of gasoline offered is superior to the motor that will burn it. They are correct in the position that knocking characteristic is just one quality in a motor fuel; this the sales division stresses and ignores others of vital importance.

This situation was aptly stated before the annual meeting of the Western Petroleum Refiners Association in Wichita, April 1 by W. W. Scheumann, chairman of the sub-committee whose subject was "Octane Number—The Refiner's Will O' The Wisp."

"It [the octane test] never can truly correlate with all types of performance on the road be-

cause such performance depends upon engine characteristics and type of operation as much as on fuel characteristics. The oil companies, therefore, have over-emphasized the value of the octane number and have mis-used it in many ways."

Despite all this, however, it is not likely that there will be hesitation in the rise of octane characteristics of motor fuel. Process are at hand to improve this quality and at the same time increase gasoline output. Although the engine maker is behind the gasoline maker today, it is not likely that he will remain there. A motor that can efficiently use 100-octane gasoline and higher is a fact for the airplane industry. It will come to the automobile. It will be an engine much smaller than the one so proudly advertised today, still it will permit higher speeds, when roads permit, and it will give the automobile owner 30 or more miles to a gallon of motor fuel instead of half that distance.

What the refining industry should do is demand a premium price for premium fuel and thus make a profit by supplying what the engine can use and its owner can afford because of more miles per gallon.

Refining does not need less technical progress. It needs more profitable progress.

PASSAGE of the appropriation measure for the Department of Interior by the House of Representatives came after adoption of an amendment to the effect that none of the appropriation "shall be used for the broadcast of radio programs designed for or calculated to influence the passage or defeat of any legislation pending before Congress."

Quick Cut at Propaganda

The amendment by Representative Ed Gossett of Texas was prompted by recent radio programs sponsored by the department, which were interpreted as being in behalf of the Cole bill. Representative Cole supported the amendment.

AN INDUSTRY operates its plants at known throughput and is amazed at the result. Such is the plight of refining. Crude oil runs are calculated from week to week and further calculation can anticipate what the result will be.

Charge It To The Weather

Still the refiner is dumfounded when gasoline stocks reach the grand total of 100,000,000 barrels.

This has been going for a decade, perhaps longer. Years back the refiner considered himself an unwilling victim of weather. He had to run at a certain capacity in winter to provide heavy fuels, consequently too much gasoline was made. In summer he had to run at a certain capacity and that resulted in too much burning oils.

What he wanted was higher consumption of burning oils in winter and higher consumption of gasoline in summer. Both of these hopes have been realized.

But the plight of the refiner has not been solved. In order to provide enough, he still has too much.

AFTER reviewing the increase in gasoline stocks in his address as president of the Western Petroleum Refiners Association, L. D. Simmons, said:

"We have reached the point where it is absolutely necessary that each of us so conduct our own operations that the aggregate stocks will be reduced to a minimum."

Tank Battery Viewpoint

His attitude is correct, since one man has influence with only one set of storage tanks.

Somehow it seems in order to question the value of the elaborate facilities for providing statistics. Each week the figures are compiled, whereby each man can know how much gasoline is in storage. When the total is too high, the individual makes complaint, usually the complaint that some other company or some other element within the industry has been making too much gasoline.

"I have been making too much gasoline," is an explanation never heard.

Perhaps lack of figures might prompt the refiner to pay attention to his own throughput instead of justifying his own business affairs by criticizing the remainder of the industry.

KEEPING gasoline taxes in a fund for road building and maintenance may become popular following a decision of the South Carolina Supreme Court, which held that the legislature of that state was without authority in diverting $2,000,000 of automotive tax funds to non-highway purposes. In part the decision read:

"We have a constitutional direction that a law which levies taxes shall distinctly state the object of the same, to which object the tax shall be applied; and a statutory imposition of a tax on gasoline and motor vehicles for the construction and maintenance of highways and for the payment of the principal of state highway certificates of indebtedness and the interest accumulating thereon."

For Road Use Only

TABLE 1
Effect of Sulfur Compounds on Lead Response

Sulfur Compound	Percent Sulfur Added	Octane No. with Cc. Lead per Gallon				
		0	1	2	3	6
Reference Fuel....	0	51.0	63.5	70.7	74.4	79.5
Methyl Disulfide..	0.39	48.9	53.0	56.2	58.7	64.5
Ethyl Disulfide....	0.03	50.4	59.9	65.6	69.4	75.4
Thiophene.....	0.105	51.0	60.5	66.4	69.8	76.3

Factors Involved in Lead Susceptibility

A. W. TRUSTY

MORE than 75 percent of the automotive fuel sold in the United States contains tetraethyl lead. Almost all aviation gasoline of 80 or higher octane number contains lead. With such use of tetraethyl lead, and with the refiner facing the future trend toward an increased use of this fluid, it may be well to review the factors involving the lead susceptibility of blending stocks.

The use of tetraethyl lead as an anti-knock blending agent has spread rapidly during the 16 years of its commercial life. The first "ethyl gasoline" was offered to the motoring public in Dayton, Ohio, on February 1, 1923. The increase in production (thousands of gallons) of leaded motor fuel is shown by the following table:

	1932	1939
Ethyl Gasoline	105,000	170,000
Leaded Regular Gasoline.....	None	1,400,000
Leaded Aviation Gasoline.....	None	10,000
Total.....	1,500	2,000,000

Leaded gasoline is sold in Canada, England, France, Australia, New Zealand, Germany and in a few other countries. In the aviation field it is used in nearly every country in the world for both military and transport purposes.

The composition of the tetraethyl lead compound has changed slightly from time to time. The approximate analysis is percent:

Tetraethyl lead	63.30
Ethylene bromide	25.74
Ethylene dichloride	8.73
Dye and impurities	2.23

The ethylene dibromide is added to the fluid to furnish halogens to combine with the lead to form lead bromide during the combustion process. The volatile lead bromide is swept out of the cylinders in the exhaust gases.*

How does the addition of tetraethyl lead to a fuel decrease the knock? The answer to this question is a matter of theory. A review of these theories shows the diversity of opinion on the subject.

DETONATION THEORY OF KNOCKING

Berthelot[1] discovered that, under certain circumstances, a detonation wave is set up during the combustion of gases or vapors. Immediately after ignition, the flame travels for some distance at a normal rate and then suddenly assumes a great velocity. Various investigators have suggested that these pressure waves are related to engine knock, but the hypothesis that a true detonation wave is set up, due to ignition of unburnt charge immediately ahead of the flame front, does not agree with experimental evidence.

The rate of rise of pressure cannot be the sole factor determining the tendency of a fuel to knock. The rate of pressure rise (1) increases with the molecular weight of the normal paraffin hydrocarbons, (2) varies inversely with the number of methyl groups attached to an aromatic nucleus, (3) is approximately the same for hydrocarbons of widely varying anti-knock properties, for example, benzene and n-octane, toluene and n-heptane, xylene and n-hexane, (4) about the same for the higher alcohols (high anti-knock compounds) as for the corresponding paraffin hydrocarbons (low anti-knock compounds), (5) is very rapid for ethyl ether.

SPONTANEOUS IGNITION THEORY OF KNOCKING

According to the theory of spontaneous ignition knocking† the knocking properties of a fuel are determined by the temperature at which it will ignite on compression by the travelling wave front. The theory therefore implies a tendency to knock proportional to the spontaneous-ignition temperature of the fuel. This theory correlates very well with actual engine practice. Thus knocking occurs more readily in large than in small cylinders because the surface-volume ratio, and therefore, the cooling, is less; more readily with paraffinic than with aromatic hydrocarbons, since the ignition temperatures of the former

*The deposits found on the piston head and cylinder walls of an engine using leaded fuels consist of lead bromide, lead sulphate, metallic lead, and lead oxides. The composition of the deposit will vary with the sulfur content of the fuel, the operating temperature of the engine and other conditions.

†The "spontaneous ignition temperature" of a substance is the temperature at which that substance, under certain specified conditions, takes fire or explodes spontaneously, without the application of a spark or flame.

are lower; more readily with paraffins of high molecular weight than with the lower paraffins for the same reason and because the flame temperature increases with the molecular weight.

It is when the effects of dopes are considered that the most trouble is found in reconciling facts with theory. Tetraethyl lead raises the spontaneous ignition temperature of a fuel, while pro-knock dopes lower the S.I.T.

The S.I.T. theory does not explain how the tetraethyl lead is effective in lowering the ignition temperature. A combination of this theory and the "peroxide theory" comes closer to an explanation of the mechanics of the action of the lead compound.

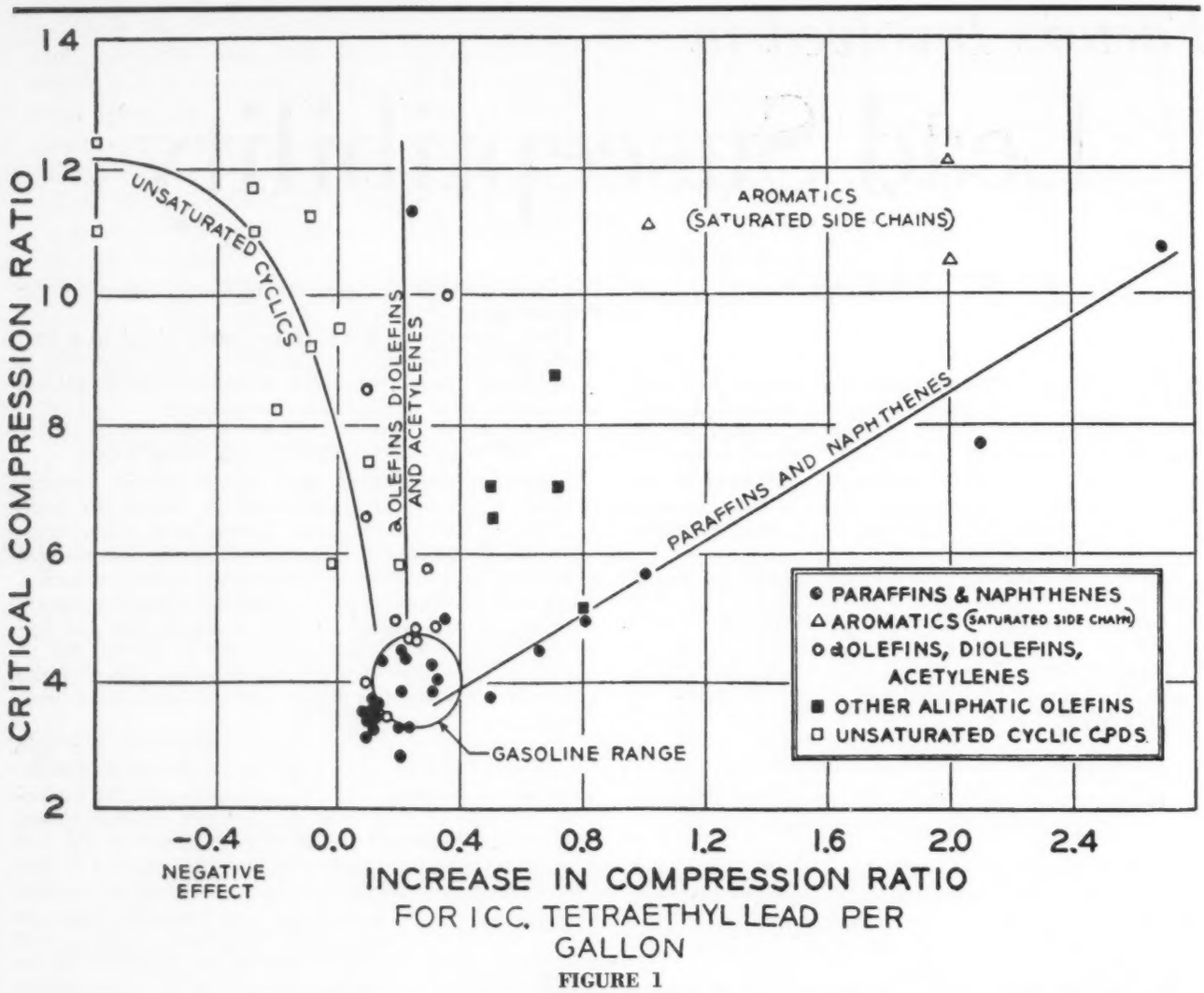

FIGURE 1

THE PEROXIDE THEORY OF KNOCKING

The combustion of a hydrocarbon, leading to the ultimate formation of oxides of carbon and water, involves the formation of various intermediate reaction products containing oxygen. One of the two theories postulates that the first product in the oxidation of a hydrocarbon is a peroxide, formed by direct chemical union of the hydrocarbon with one molecule of oxygen. It is known that,

(1) Hydrocarbons begin to oxidize in the presence of air at low temperatures. Thus, with a 10-percent mixture of hexane in air, traces of oxidation products of the hydrocarbon, namely, water, aldehydes, and carbon dioxide have been obtained at 617°F.

(2) Knocking fuels give these oxidation products much more readily than non-knocking fuels, or fuels of high anti-knock rating.

(3) Organic peroxides have pronounced pro-knock action when added to motor fuels, the more unstable peroxides such as acetyl diperoxide having a more pronounced effect than comparatively stable peroxides such as benzoyl peroxide. Many peroxides are explosive when heated suddenly.

(4) When tetraethyl lead is added to a fuel, the amount of peroxides formed in low temperature oxidation experiments or during the compression stroke in engine operation is much reduced. Pro-knock substances such as ether and amyl nitrite have the reverse effect.

The peroxide theory of knocking is widely accepted; however, there have been criticisms from many workers who have found some unexplainable exceptions.

The one effect of the presence of tetraethyl lead in a gasoline upon combustion is to prevent the extremely rapid inflammation of the latter portion of the charge, and the accompanying pressure rise,

which is the knock. Tetraethyl lead has no effect upon the velocity or the character of the flame prior to the time at which knock would have occurred in its absence.

LEAD SUSCEPTIBILITY OF PURE HYDROCARBONS

It is common experience in refining operations to find wide variations in lead susceptibility of blending stocks used in the finished gasoline. This variation would indicate that there probably would be more marked differences in the lead susceptibility of the individual hydrocarbons.

Campbell[3] and associates studied the blending effect of tetraethyl lead in 62 pure hydrocarbons in a single-cylinder, variable compression engine. The anti-knock values were determined by finding the increase in the critical compression ratio made possible by the addition of 1.0 c.c. of tetraethyl lead per gallon of hydrocarbon. A summary of the data is given.

Some very interesting conclusions can be drawn:

(1) The lower-boiling paraffins and naphthene, or those hydrocarbons with the highest anti-knock values, are most lead susceptible. There is a marked difference between the light and heavy hydrocarbons.

(2) The aromatics are fairly susceptible to tetraethyl lead. Aromatics with a saturated side chain are more reactive to lead than when the saturated side chain is replaced with an unsaturated side chain.

(3) The unsaturated hydrocarbons on the other hand show much less variation in lead susceptibility, regardless of their original octane number.

As the double bond progressively moves towards the center of the molecule, the effectiveness of lead in the compound increases. With a number of unsaturated hydrocarbons, lead has a "negative" effect, that is, the octane number is actually lowered by the addition of tetraethyl lead. Figure 1 shows graphically the effect of lead on the hydrocarbon groups. Apparently the presence of unsaturated cyclic compounds in certain types of cracked gasolines account for the low lead susceptibilities of these fuels.

EFFECT OF SULFUR COMPOUNDS

The presence of sulfur compounds in gasoline decreases the octane number and lead susceptibility. The magnitude of this effect depends not only on the quantity of total sulfur compounds present but on the type. Schulze and Buell[4] have shown that polysulfides are among the worst offenders, followed by disulfides, mercaptans, thioethers and thiophenes.

It was shown that with the aliphatic series the harmful effect of the disulfide increases with increasing molecular weight; side chains also decrease the effectiveness of the lead. The heat stability of the sulfur compounds is a good indication of the effect on lead susceptibility, the more stable sulfur compounds, such as the thiophenes, have the least effect on the effectiveness of the lead.

It is a common experience in refinery practice to find that the doctor-sweetened gasoline is less susceptible to lead than was the sour gasoline. During the doctor treatment the less harmful mercaptans were converted into the more harmful disulfides and in some cases the polysulfides.

A preliminary caustic wash before the doctor treatment has been found effective in raising the lead susceptibility of certain gasolines. The lower-boiling mercaptan sulfur compounds are entirely removed

TABLE 2

COMPOUND	Critical Compression Ratio	Increase in Critical Compression Ratio for Addition of 1 Cc. of Tetraethyl Lead per Gal.
PARAFFIN HYDROCARBONS		
n-Pentane	3.8	0.50
2-Methylbutane	5.7	0.95
n-Hexane	3.3	0.20
n-Heptane	2.8	0.20
3-Ethylpentane	3.9	0.20
2,4-Dimethylpentane	5.0	0.80
2,2,4-Trimethylpentane	7.7	2.10
2,7-Dimethyloctane	3.3	0.20
3,4-Diethylhexane	3.9	0.30
OLEFIN HYDROCARBONS		
1-Pentene	5.8	0.30
2-Pentene	7.0	0.50
2-Methyl-2-butene	7.0	0.70
Dimethylbutadiene	8.6	0.10
2,4-Hexadiene	6.6	0.10
1,5-Hexadiene	4.8	0.25
1-Heptyne	4.9	0.33
3-Heptyne	3.4	0.10
1-Heptene	3.7	0.25
3-Heptene	4.9	0.80
3-Ethyl-2-pentene	6.6	0.50
2,4-Dimethyl-2-pentene	8.8	0.70
2-Methyl-5-hexene	4.7	0.25
3-Methyl-5-hexene	5.0	0.20
2-Octyne	4.0	0.10
1-Octene	3.4	0.15
2,2,4-Trimethyl-3-pentene	10.0	0.35
2,2,4-Trimethyl-4-pentene	11.3	0.25
NAPHTHENE HYDROCARBONS		
Cyclopentane	10.8	2.70
Cyclohexane	4.5	0.65
Methylcyclohexane	4.6	0.30
Cyclohexylacetylene	4.6	0.21
1,2-Dimethylcyclohexane	5.1	0.35
1,3-Dimethylcyclohexane	4.4	0.21
1,2-Methylethylcyclohexane	4.3	0.16
1,3-Methylethylcyclohexane	3.8	0.12
1,4-Methylethylcyclohexane	3.7	0.13
NAPHTHENE HYDROCARBONS		
1,2-Methyl-n-propylcyclohexane	3.6	0.12
1,3-Methyl-n-propylcyclohexane	3.4	0.12
1,4-Methyl-n-propylcyclohexane	3.3	0.12
1,4-Methylisopropylcyclohexane	4.0	0.26
1,2-Methyl-n-butylcyclohexane	3.4	0.10
1,3-Methyl-n-butylcyclohexane	3.3	0.10
1,4-Methyl-n-butylcyclohexane	3.2	0.10
1,2-Methyl-n-amylcyclohexane	3.2	0.10
Decahydronaphthalene	3.6	0.13
AROMATIC HYDROCARBONS		
Phenylacetylene	12.4	—0.80
Ethylbenzene	10.5	2.00
Benzylacetylene	7.4	0.12
Methylphenylacetylene	11.8	—0.30
1,4-Methylisopropylbenzene	11.1	1.00
1-Phenylbutadiene	9.5	0.00
Tert-Amylbenzene	12.1	2.00
Trimethylphenylallene	8.3	—0.20
UNSATURATED CYCLIC HYDROCARBONS		
Cyclopentadiene	10.9	—0.90
Dimethylfulvene	9.2	—0.13
Indene	11.2	—0.10
Dicyclopentadiene	11.0	—0.30
Cyclopentene	7.9	0.20
1,3-Cyclohexadiene	5.9	—0.02
Cyclohexene	4.8	0.20
Dipentene	5.9	0.25

Lead Blends on Gasolines Produced by Various Refining Processes

TYPE OF GASOLINE	Initial	End Point	Percent Sulfur	Remarks	Octane Number With Cc. Lead Per Gal. 0	1	2	3
Natural Gasoline	60.0	333	.005	26 lb V.P.	72.0	85.4	87.4*	....
Natural Gasoline	78.0	335	.005	18 lb V.P.	66.7	81.0	86.0	....
Natural Gasoline	85.0	329	.010	13 lb V.P.	62.7	77.0	82.8	85.3
Straight-run gasoline from Rodessa crude	105	325	.005	6 lb V.P.	48.5	62.0	72.5	76.5
Straight-run gasoline from East Texas crude	95	360	.01	10 lb V.P.	61.5	73.5	80.5	82.0
Straight-run gasoline from California crude	146	435	.29	.....	62.5	69.0	72.5	75.0
Cracked gasoline, California crude	108	402	.09	.....	66.0	73.0	75.5	....
Cracked gasoline	100	390	.07	59 A.P.I.	63.0	68.5	71.5	74.0
Cracked gasoline	100	435	.30	56 A.P.I.	70	72.5	75.5	76.5
Reformed gasoline	95	396	.....	53 A.P.I.	69.0	75.0	78.0	79.0
Catalytic Polymer Gasoline	95	414	.....	76 A.P.I.	70.0	75.0	77.0	78.5
Catalytic Polymer Gasoline	95	414	.....	71 A.P.I.	82.5	84.0	85.0	85.5

*1.5 c.c. lead per gallon.

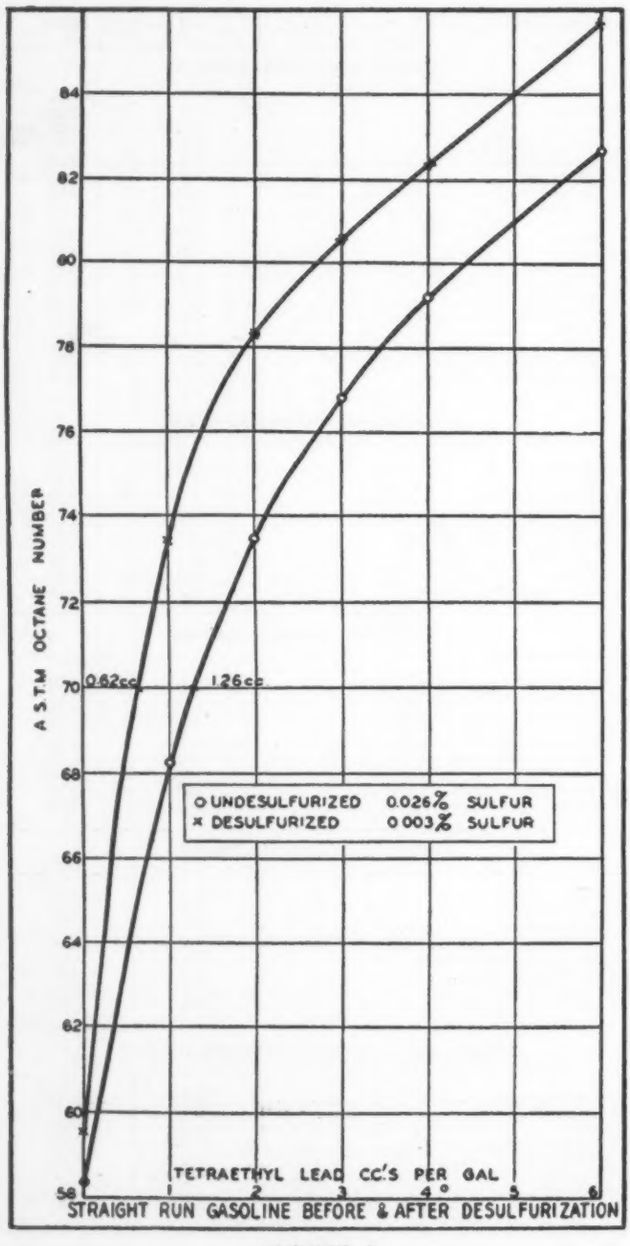

FIGURE 2

by the caustic wash; the reduction in total sulfur thus lowers the lead requirement. For example, a cracked gasoline:[2]

	Untreated Gasoline	Multiple Caustic Washed Gasoline	Doctor Treated Gasoline
Octane No., A.S.T.M.	61.0	61.0	59.0
Octane No., with 1 Cc. lead	68.5	69.0	66.0
Octane No., with 2 Cc. lead	71.5	73.0	70.0
Octane No., with 3 Cc. lead	74.5	76.5	72.0

The lead requirement to blend to a certain octane number is doubled by the presence of only a small amount of sulfur. For example:

Straight-run Gasoline from	Rodessa, La., Crude	Magnolia Co., Ark., Crude
Octane Number (Motor Method)	48.5	54.0
Cc. lead to make 72 Octane Number	1.8	3.0
Sulfur, percent	0.005	0.03

Fortunately, increasing the sulfur content of a gasoline does not decrease the lead susceptibility in the same proportion.

Several processes have been offered for vapor phase desulfurization of straight-run and cracked naphthas. The lead susceptibility of the treated naphthas is considerably improved by the reduction in total sulfur content.

EFFECT OF ACID TREATMENT

Acid treatment of cracked gasolines removes sulfur compounds and certain of the unsaturated hydrocarbon constituents. The removal of the unsaturates results, in general, in a lowering of the octane number, but by the removal of these same hydrocarbons, the lead susceptibility is raised.

Natural gasoline has in general the highest susceptibility to tetraethyl lead of all commercial blending stocks.

Low-sulfur, paraffin base, straight-run gasolines have the next highest effectiveness to the addition of lead.

High-sulfur, naphthene base, straight-run gasolines are considerably less reactive to lead blending than the low-sulfur, paraffin-base gasolines.

Cracked gasolines have lower lead susceptibilities than straight-run products—the degree depending on the sulfur content and the extent of cracking to which the stock was subjected.

[1] Motor Fuel Preparation and Application. Nash. Page 745.
[2] Ind. Eng. Chem. Vol. 31, No. 21, Page 1440.
[3] Ind. Eng. Chem. Vol. 27, No. 5, Page 593.
[4] Oil Gas Journal, Oct. 10, 1935, Page 22.

Treatment of High-Sulfur Cracked Distillate *With* Stratcold Process

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C. A. DAY, JR.
Richfield Oil Corporation

DURING 1939 a Stratcold treating plant, incorporating the latest improvements, was installed at the Watson refinery of Richfield Oil Corporation in California. Completion of this unit has brought the refinery operations to a point where flexible and economic control of the sulfur content of finished gasoline is readily maintained. Precise control is essential since the refinery processes California crudes rich in sulfur compounds.

In the refining procedure, cracked distillate is split into a heavy and light fraction by the usual debutanizing and stabilizing operations. The heavy fraction, having a boiling range of 220°F. to 410°F., contains the refractory sulfur compounds and is subjected to the Stratcold treatment; the light fraction contains sulfur compounds which are satisfactorily removed by caustic washing. The acid treated distillate is rerun and the overhead blended with the caustic-washed light fraction for sweetening.

The flow of the Stratcold process is shown in Figure 1. Briefly, cracked distillate is contacted in three stages with counter-current flow of acid. The treated distillate is then passed upward through a clarifier or rock-packed tower for further separation of acid sludge, thence water washed, and finally neutralized with caustic soda solution.

The plant was designed to treat 11,000 barrels per day of heavy cracked naphtha with 9 pounds of 98 percent sulfuric acid per barrel of naphtha with temperatures on the stages maintained at 30°F., 30°F., and 20°F., respectively.

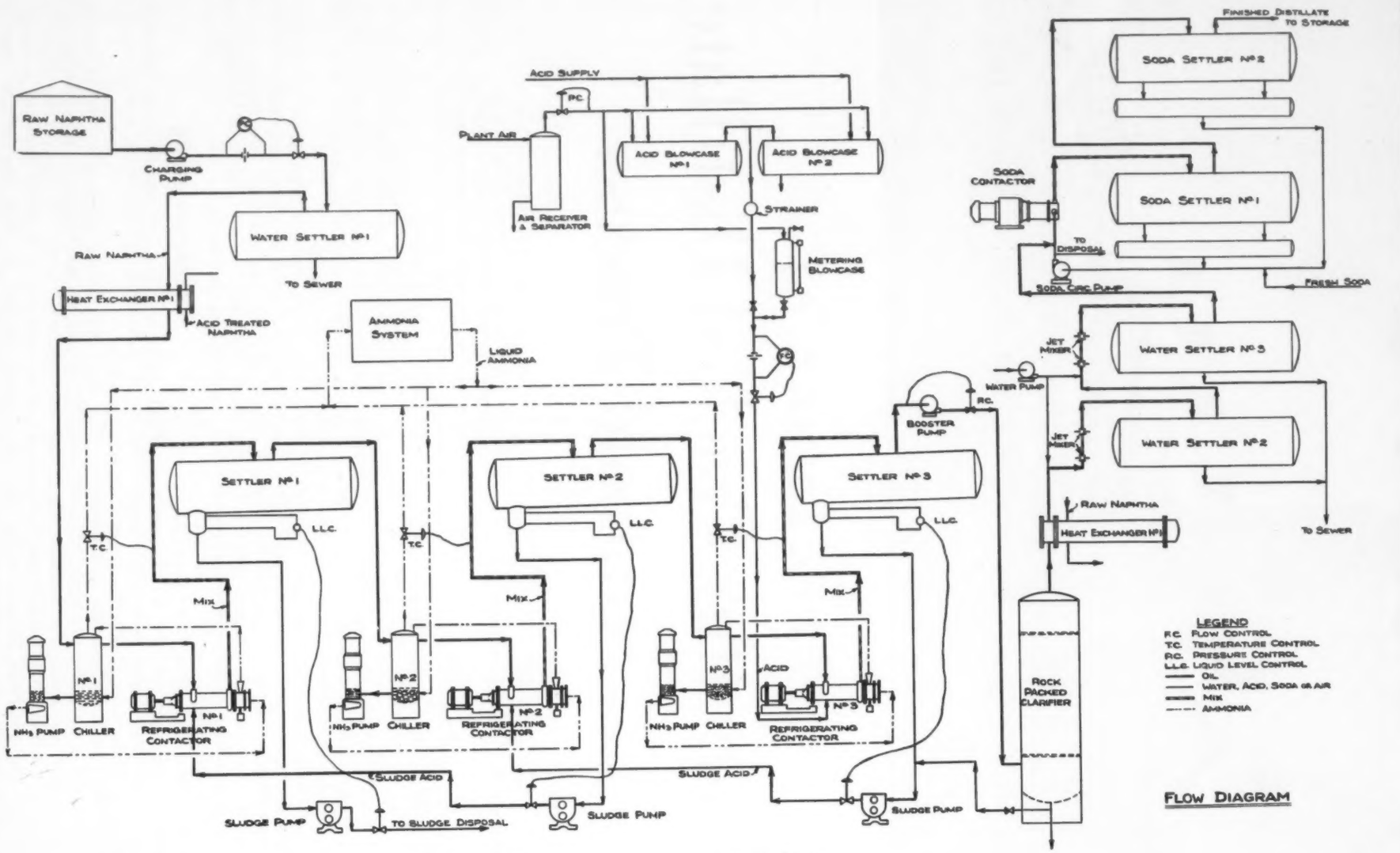
Stratford Engineering Corporation designed and constructed the plant in close cooperation with the Richfield-Sinclair engineering departments so that the plant conforms to the Richfield-Sinclair design and construction standards.

TREATING STAGE

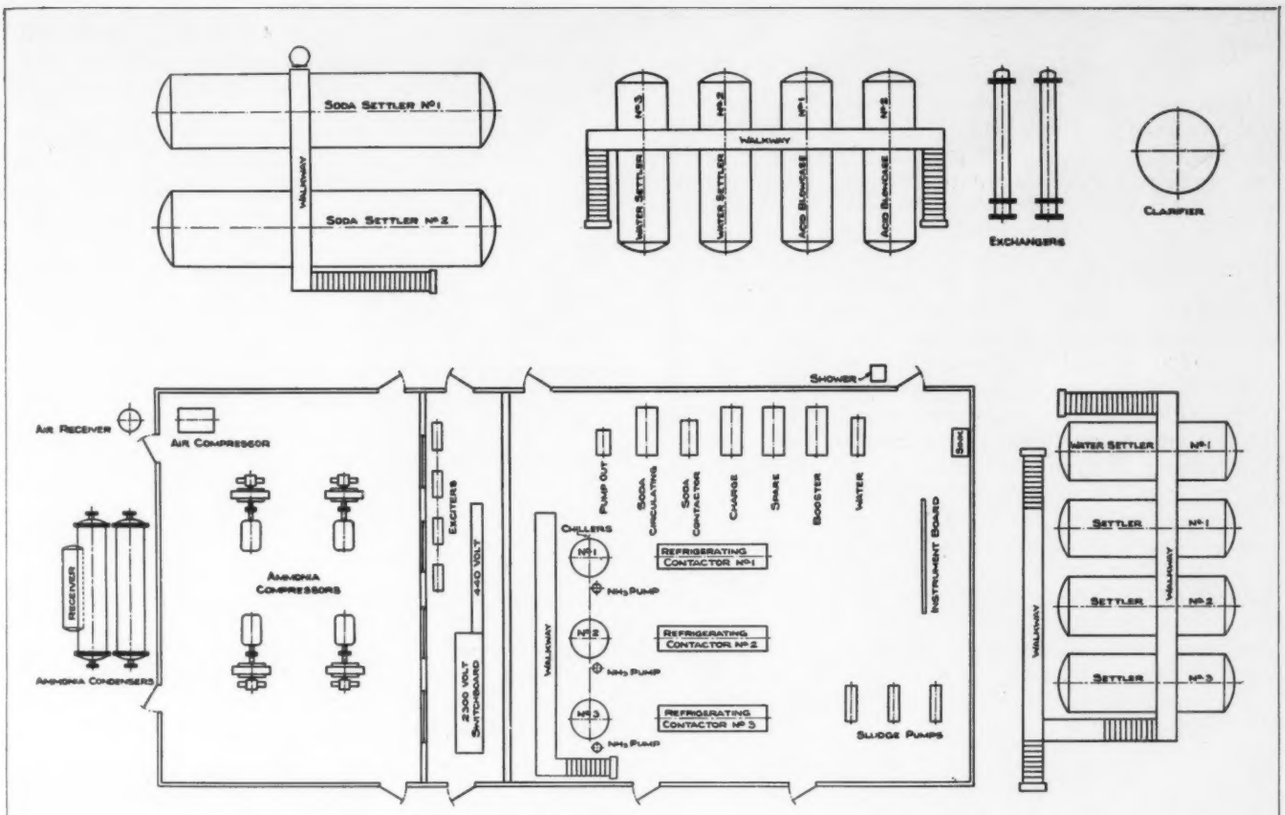
Each stage of the treating process comprises a chiller, a horizontal refrigerating contactor, and a sludge settler.

The distillate before passage to the contactor is cooled to treating temperature in the chiller which is the shell-and-coil type, arranged with liquid-level control to maintain a constant level of ammonia in the bottom portion. A clear non-frosting gage glass provides a visible check of this level.

In the refrigerating contactor, acid and distillate



Flow Diagram—Stratcold Acid Treating Plant



PLOT PLAN

Plot Plan—Stratcold Acid Treating Plant

are rapidly circulated by an impeller over tubes cooled by ammonia. Thus, in one operation, acid and distillate are intimately mixed and the heat of reaction removed as rapidly as produced. Ammonia is supplied to the tubes by a vertical, centrifugal pump (mounted on the chiller) which pumps liquid ammonia from the base of the chiller through the refrigerating head of the contactor back to the ammonia vapor zone of the chiller.

SETTLERS

All settlers are Stratco design incorporating special decelerating features and are protected by relief valves.

The initial settler, sludge settlers, clarifier and soda settlers are steel vessels designed and constructed in accordance with the API-ASME code for unfired pressure vessels with ⅛-inch corrosion allowance. The two water settlers for separation of acid water

TABLE 1
Test Run Data

Commercial Test / **Number of Days**	**1** / **5**	**2** / **3**	**3** / **5**	**4** / **7**	**5** / **15**	**6** / **14**	**7** / **14**
Rates No./Barrels:							
Acid	6.64	6.57	5.08	4.43	4.53	4.54	3.92
Caustic Soda	....	.20	.11	.07	.07	.06	.08
Temperature °F.:							
1st Stage	30	40	40	40	50	60	60
2nd Stage	30	30	30	40	50	60	60
3rd Stage	20	20	20	30	40	50	50
Capacity and Losses:							
Treated Distillate, percent	96.27	95.51	96.55	96.49	97.14	96.92	97.29
Net Yield 400 EP Treated Distillate, percent	93.05	92.73	93.92	93.64	93.61	93.38	93.98
Treating Loss, percent	3.73	4.49	3.45	3.51	2.86	3.08	2.71
Polymer Loss, percent	1.81	1.82	1.74	2.07	2.34	2.15	2.05
Mercaptan Sulfur—Mgs/100 Cc:							
400 EP in Feed	50	50	50	50	50	50	50
400 EP in Treated Distillate	2	4	5	6	15	10	14
Percent Sulfur:							
Feed	.630	.663	.671	.671	.648	.641	.678
Treated Distillate	.423	.431	.451	.504	.495	.445	.492
400 EP in Feed	.600	.636	.643	.651	.618	.613	.633
400 EP in Treated Distillate	.248	.248	.329	.337	.315	.272	.340
Octane Number:							
400 EP in Feed	....	....	....	....	68.2	67.9	68.6
400 EP in Treated Distillate	....	....	....	....	67.1	67.0	67.7
Loss	....	....	....	....	1.1	0.9	0.9
C. D. Gum:							
400 EP in Feed	146	....	....	....	450	500	486
400 EP in Treated Distillate	5	....	....	....	20	37	22
Color of 400 EP in Treated Distillate	30	30	30	30	30	30	30

It should be noted that the sulfur removal on the above treats is not on the same reduction basis.

are made of bronze with 1/16-inch corrosion allowance.

REFRIGERATION

Heat exchange is provided between the raw feed and the cold-acid-treated distillate, as it leaves the clarifier, to reduce the refrigeration load. This load is further reduced by adequate covering of cold lines and vessels with vegetable cork insulation.

Four vertical, two-cylinder ammonia compressors constitute the refrigerating capacity. These take suction on the chillers and discharge through water coolers into a receiving drum from which liquid ammonia is returned to the chillers. The compressors are manifolded in such a manner that each may be operated with any one of the chillers. Also, adjustments are provided on each compressor which permit setting the output at one third, two thirds, or full capacity, thus giving desired flexibility for adjustment with varying lead requirements.

Each compressor is directly connected to a 2300-volt synchronous motor. Each motor is vapor-proofed by a separate fresh air system which forces air through the collecting ring enclosures. This air supply is assured at all times since the motors cannot be started until the air blower is in operation, and, in the event of failure, motors are automatically stopped.

The ammonia system is provided with an automatic air purging unit.

PUMPS

All pumps are motor driven with the exception of one steam pump provided for special pump-out service. The motors used are 440-volt explosion-proof induction type.

A spare centrifugal pump is provided which can be used either in charge or booster pump service. A Stratco standard horizontal high-dispersion contactor is used to contact caustic with water washed distillate.

Positive displacement pumps of the rotating plunger type are used in acid-sludge service. These pumps are controlled by liquid level controllers actuated by the differential pressure between the naphtha space and acid space of the sludge settlers.

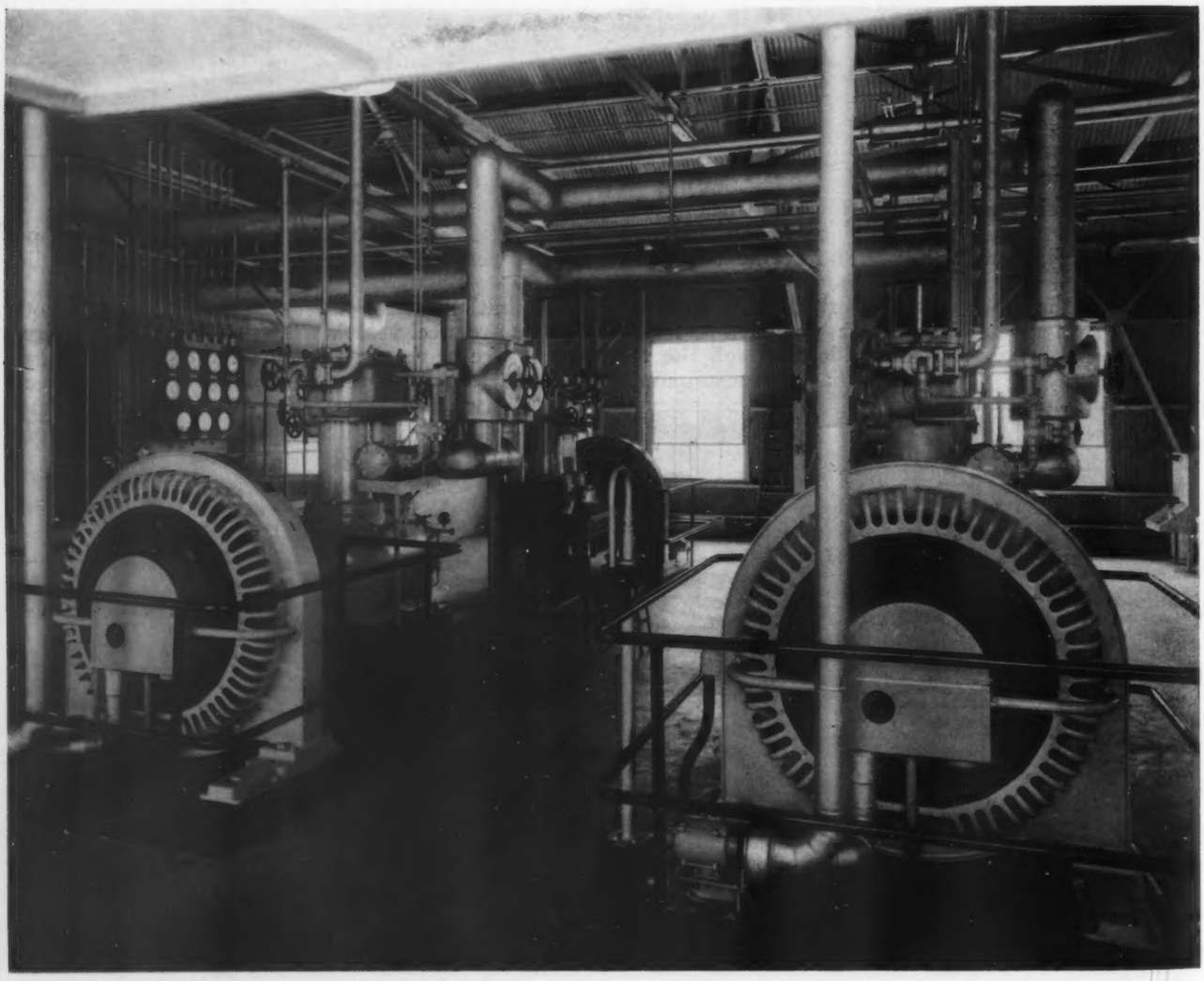
PIPING AND VALVES

The only special piping is the bronze lines which handle weak acid solution.

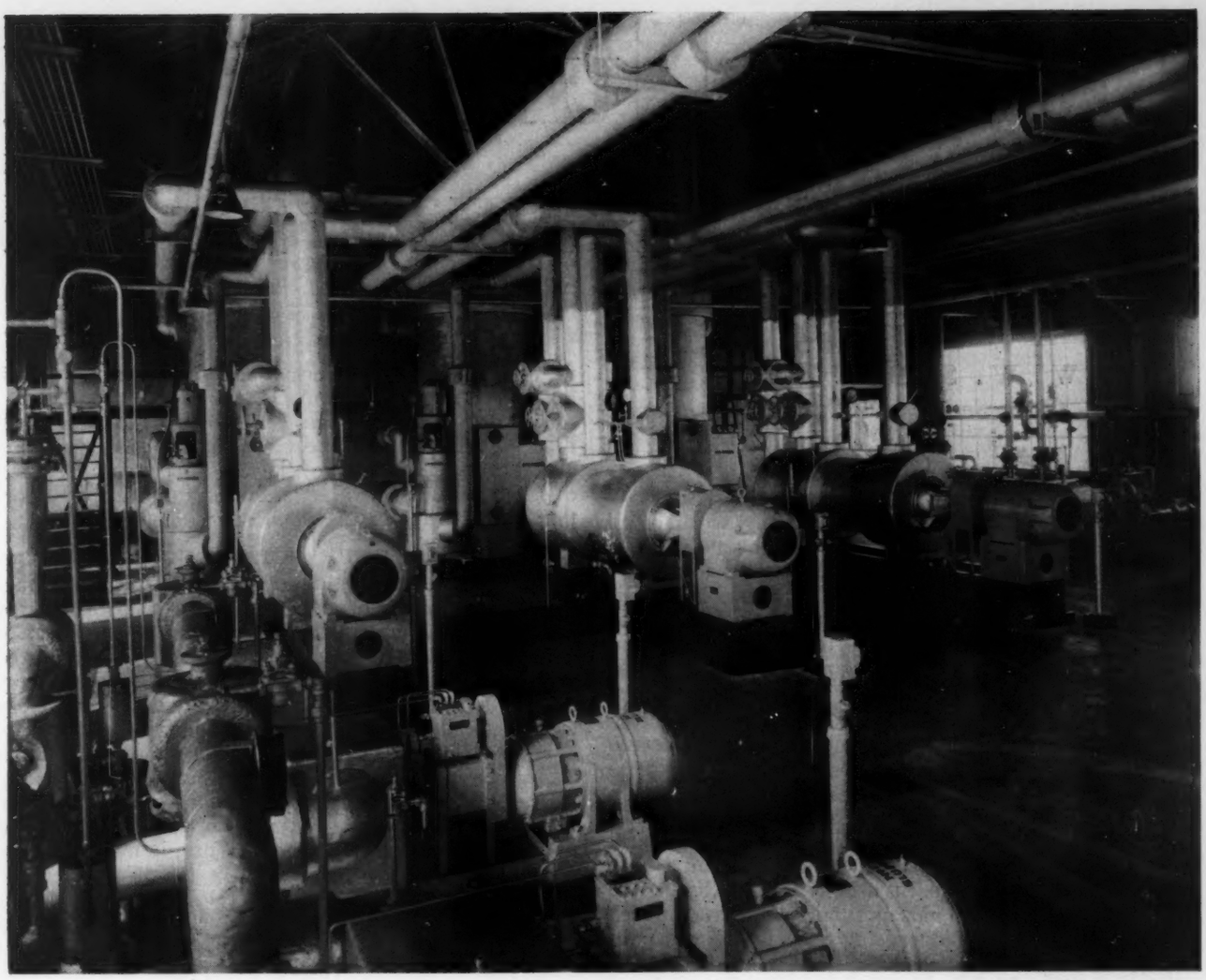
The valves throughout the unit are the plug-cock type except those on ammonia equipment, instruments, and sample lines, which are the usual type required for such service.

INSTRUMENTATION

The instrumentation of the treating unit gives maximum flexibility in control and reduces operating attention to a minimum. The instrument board is one of the largest which has been installed in a Stratcold plant and consists of a single unit. Before this board



Interior of refrigeration compressor room in Stratcold acid treating plant. Lines and vessels are insulated with cork.



Chiller, contactors and pumps in Stratcold acid treating plant. Pumps are driven by explosion-proof induction type motors.

the operator has a complete, continuous picture of each step of the operation.

Aside from several pressure-indicating gages, the instrument board shows acid rate, distillate rate, stage temperatures, sludge levels, ammonia pressure in the chillers, and differentials indicating the liquid ammonia circulation from the chillers.

The booster pump is provided with a pressure controller on the suction. This instrument prevents pressure surges in the sludge settlers.

The unit is amply provided with thermowells and pressure gages.

Pressure-regulated air is supplied to the instruments and acid blow cases.

The building which houses equipment indicated in the plot plan (Figure 2) is steel frame and corrugated asbestos construction. It is divided into three rooms: contactor, compressor, and electrical. The middle or electrical room runs through the width of the building and is sealed off from the other two rooms. Four fixed steel-sash windows fitted with polished wire glass are provided in the wall on the compressor room side. The wall on the contactor room side is solid concrete. The room has only outside entrances and is kept under slight fresh air pressure by a blower to protect against the possible entry of inflammable gas. Contained in this room are exciters for the ammonia compressors and switchboard with panels arranged systematically for 2300-volt and 440-volt incoming power and starting equipment.

All light fixtures and switches convenient to the operator are vapor-proof or explosion-proof type.

At one of the entrances to the contactor room an emergency shower, turned on by stepping on the grating beneath it, is provided.

OPERATING RESULTS

From the first, the operation of the plant has been extremely smooth and free of difficulties.

The performance of the unit is illustrated by the data in Table 1 which covers a number of test periods. The several changes in operating conditions were made to explore the flexibility of the unit and to find the economic level for the degree of desulfurization required. When test number seven was made, the refinery gasoline sulfur balance required only 0.35 percent sulfur in the heavy cracked naphtha. The apparent octane loss on these tests was approximately 1.0.

Power consumption per barrel of charge varies between 0.90 and 0.70 KW with 0.46 and 0.26 KW of these figures representing power for refrigeration.

Consumption of caustic soda appears to stabilize between 0.060 and 0.080 pounds (dry) per barrel of feed.

Octane Number

The Refiner's Will-O'The-Wisp

W. W. SCHEUMANN
Cities Service Oil Company

ACCORDING to some historians, there was released on or about May 29, 1930, to a waiting world of oil refiners, the first knowledge concerning the arrival of a new test for motor fuel quality, called the "octane number." A little over a year later, in August, 1931, this became official when the Cooperative Fuel Research Steering Committee released a tentative method for measuring or determining the octane number of a motor fuel.

The concept of anti-knock gasoline was well established by that time, and the petroleum industry lost no time in adopting this method for measuring the anti-knock value of its motor fuels. In fact, it breathed an audible sigh of relief over the fact that it could now discard such things as benzol equivalent, highest useful compression ratios, and other pet schemes which individual companies had been using, but which no one except laboratory technicians understood and which even the most adroit advertising agent could not publicize. The octane number, on the other hand, fell along a simple but comprehensive scale, it lent itself readily to sales promotion and advertising, and it was believed to predict road performance fairly well. As a result, the doctrine that higher octane numbers were synonymous with higher quality was taken as a matter of course and little heed was given to the fundamental limitations and significance of the method. The refining industry began to follow the octane will-o'the-wisp and nine years later is still following it, and finding it as elusive as ever.

WHY OCTANE NUMBERS

The need for such a test as the octane number came with the advent of anti-knock gasoline. Anti-knock value as an abstract quality has little practical value. It is usable only when it can be defined and measured in accordance with some accepted standard. The refiner, therefore, needs a standard means of evaluating the anti-knock characteristics of his gasoline, the automotive engineer needs such information in order to design engines, and perhaps even the consumer has some justification in wanting information as to the anti-knock quality of the fuel he buys.

The octane number was conceived in the high hopes that it would fill this requirement and that it would give a proper evaluation of the anti-knock characteristics of a motor fuel. Its value is, therefore, directly proportional to the degree in which it accomplishes this.

WHAT IS THE OCTANE NUMBER?

When we examine the octane number, we find that it is not an intrinsic or inherent characteristic of a motor fuel. Rather, it is an arbitrary measure of the relative detonating performance of a motor fuel when compared with a mixture of two pure hydrocarbons in a very special single-cylinder engine, operated under very closely specified and controlled conditions.

Here at the very start, we can point out several fundamental limitations of this test. What we are actually interested in is the knocking characteristics of the fuel in service. However, in service the fuel is used under a multitude of engine conditions, in multi-cylinder engines of various designs and in various degrees of mechanical perfection, all of which have an important bearing on the behavior of the fuel, but of which no cognizance is taken in the test method.

The basic reference fuels are two pure hydrocarbons. One of them, n-heptane, is a straight-chain paraffin and the other, iso-octane, is a branched-chain paraffin. There are no commercial gasolines having a similar chemical composition and we can, therefore, hardly expect that a gasoline which matches a definite blend of these reference fuels under the test conditions would bear the same relationship under some other engine condition. Furthermore, there is also no reason why two gasolines, which match the same blend of reference fuels under the test conditions (that is, have the same octane number) but have different chemical compositions, should maintain this relation when engine conditions are changed. A study of the octane number test method itself, therefore, indicates little hope that it might give results which cover service requirements.

HOW DO OCTANE NUMBERS RELATE WITH ROAD PERFORMANCE?

The relationship of laboratory octane numbers with road performance has been the subject of extensive cooperative study. After the C. F. R. Committee released its first octane-number-test method in 1931, it still had one fundamental objective to accomplish, namely, to determine the relation between the laboratory test and road performance in cars and, if necessary, to modify the test procedure so as to agree with the road tests.

The first of such tests was made in 1931 by a special subcommittee who used 6 fuels, testing them in 13 cars. Considering all the fuels and all the cars, it was found that the cars said the fuels had octane numbers which

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*This non-technical discussion of octane number methods was prepared under the direction of a special W.P.R.A. committee consisting of the following:
R. C. Alden, Phillips Petroleum Company, Bartlesville, Oklahoma.
H. T. Bennett, Mid-Continent Petroleum Corporation, Tulsa.
W. M. Carney, Lion Oil Refining Company, El Dorado, Arkansas.
E. Dunning, Shell Oil Company, St. Louis.
B. C. Frichot, Deep Rock Oil Corporation, Cushing, Oklahoma.
F. S. Horne, Bareco Oil Company, Barnsdall, Oklahoma.
R. W. Leslie, Skelly Oil Company, Eldorado, Kansas.
W. W. Scheumann, Cities Service Oil Company, Tulsa.
Delivered before general session of the twenty-eighth annual meet- of the Western Petroleum Refiners Association, Wichita, Kansas, March 31, April 1 and 2, 1940.

extended from 5 octane numbers higher than the laboratory rating to a value of 20 octane numbers lower than the laboratory ratings. The overall average road rating was slightly less than 4 octane numbers below the laboratory rating. (This laboratory method was later named the Research Method and is now known as the 1931 Research Method.)

These tests indicated that, on the average, automobiles rated fuels almost 4 octane numbers lower than the laboratory-research method, although a given combination of car and fuel might show any result from 5 octane numbers higher to 20 octane numbers lower.

In 1932, the first of the Uniontown tests was conducted. These tests were primarily for the purpose of determining a satisfactory road rating on a number of fuels, and modifying the laboratory method so that it would agree more nearly with the average of the road results. It was recognized that no single test method could be expected to do any more than approximate the average.

These tests were a practical check of the 1931 results in that they showed that, considering an average of all cars and all fuels, the Research Method rated fuels 4 octane numbers higher than the road tests in automobiles indicated. However, a given combination of fuel and car might produce road octane numbers which were anything from over 3 octane numbers better than the laboratory to 23 octane numbers poorer than the laboratory test.

The C.F.R. Motor Method for octane numbers was developed to match the average of the 1932 Uniontown road tests. It did this precisely. Considering all fuels and all cars, the average road results agreed identically with the Motor Method octane number; however, the combination of a given car and a given fuel might result in road values which were anything from almost 8 octane numbers higher to 13 numbers lower than the results of the laboratory method.

The Motor Method differed from the Research Method in that it tested fuels under engine conditions which were considerably more severe. As a result, numerical values for octane numbers were lowered in general by the use of this method. Sensitive gasolines, such as highly cracked gasolines, showed depreciations as high as 9 octane number units. Straight-run or mildly cracked gasolines showed lower depreciations, the extreme being highly paraffinic gasolines, such as Pennsylvania straight-run, which were actually of higher numerical value by the Motor Method than by the Research Method.

In spite of the vigorous objections of many refiners who objected to the lower numerical values given their gasoline by the new method, the Motor Method quickly replaced the Research Method for general use, and the method was so highly regarded that it was adopted by the A.S.T.M. as a tentative standard in 1933, and thus became the CFR-ASTM method. It is the only knock-test method that has been accepted by the American Society for Testing Materials, and it is significant to note that it is now included in many state and federal specifications.

However, by 1934, there was wide-spread opinion that the relation between the performance of fuels in automobile engines and the A.S.T.M. octane number lacked considerable of showing close correlation. A test program was therefore arranged, which was known as the 1934 Uniontown Tests.

These tests corroborated the opinion of poor correlation. It was found that taking an overall average of all fuels and all cars, the average road rating was about one half an octane number higher than the A.S.T.M. octane number indicated. However, any one particular combination of fuel and car might give a result which would be anywhere from 8.5 octane numbers better than the A.S.T.M. octane number to 5.5 octane numbers below this value. In addition, certain fuels rated consistently high in most cars, while other fuels rated consistently low in most cars. Some fuels, however, rated high in certain cars and low in others, while other fuels rated in the opposite manner in the same cars. The same was found to be true of cars. Some cars rated all fuels consistently high and others rated all fuels consistently low. On the other hand, some cars rated certain types of fuels higher than the laboratory, and other types of fuels lower than the laboratory, while other cars rated these same types of fuels in the opposite manner.

When the road results were compared with the laboratory Research Method octane numbers, the divergence was still greater. Considering all fuels and all cars, the average road rating was 2.5 octane numbers lower than the Research Method octane number. However, any one particular combination of car and fuel might fall anywhere from 4 octane numbers above the laboratory value to 14 octane numbers below the laboratory value. The same behavior of fuels and cars also existed on this basis of comparison as described previously.

In general, therefore, the correlation of Research Method octane numbers with road performance was poorer than the correlation with A.S.T.M. octane numbers and the latter was retained as the standard method for want of anything better.

L-3 METHOD

Late in 1936 the industry decided a new method was necessary and that it needed an octane-number-test method which was less severe than the A.S.T.M. Method but more severe than the Research Method. After several methods had been investigated, one was found which gave results that on the the average were equal to the A.S.T.M. octane number plus 29 percent of the difference between the A.S.T.M. and Research Methods. This was called the L-3 Method, and came into general use during 1937.

During this same year, under the direction of technicians of the petroleum industry a very comprehensive road-test program was carried out on both winter- and summer-grade fuels in order to again determine the degree of correlation between road performance and laboratory octane numbers.

Considering first the winter fuels, tested during the winter season, it was found that, including all fuels and all cars, the average road octane number was slightly under 1 octane number higher than the A. S. T. M. octane number, about 1 octane number lower than the L-3 octane number, and about 2.5 octane numbers lower than the Research octane number. However, for any combination of fuel and car, the road octane number might fall anywhere from 13.5 numbers higher than the A. S. T. M. octane number to 5.5 octane numbers lower or, in the case of the L-3 Method, from 11.5 octane numbers higher than the laboratory to 7.5 numbers lower than the laboratory or, with the Research Method, from almost 8 octane numbers higher to 11.5 octane numbers lower than the laboratory.

On the summer fuels, tested during the summer season, it was found that, including all fuels and all cars, the average road octane number was only several tenths of an octane number higher than the A. S. T. M. value, or about 1.5 octane numbers lower than the L-3 value and about 2.5 octane numbers lower than the Research value. However, for any combination of fuel and car,

the road octane number might fall anywhere from 9 octane numbers higher than the A. S. T. M. value to over 4 octane numbers lower, or in the case of the L-3 Method, from 8.5 numbers higher than the laboratory to 6 numbers lower than the laboratory method, or with the Research Method, from 5 octane numbers higher to 8 numbers lower than the laboratory.

These tests also showed that certain fuels were rated consistently higher on the road than in the laboratory, while other fuels were rated in the opposite order by the same cars. Conversely, the same may be said of automobiles. Some cars rated all fuels consistently high and others rated all fuels consistently low. On the other hand, some cars rated certain types of fuels higher than the laboratory and other types lower than the laboratory, while other cars rated these same fuels in the opposite manner.

In general, therefore, these tests show that, if we were to consider all the gasolines marketed and all the cars in which that gasoline is used and strike an overall average, the A. S. T. M. octane number would come fairly close to indicating the anti-knock performance that might be obtained, the L-3 Method would rate the fuels too high, and the Research Method would rate them considerably too high. But for any given fuel, any given car or any combination of the two, the road results could be either considerably better or considerably poorer than the laboratory indications by any of these octane-number methods. This deviation of road performance from laboratory results might range from +10 to —7 units for the A.S.T.M. and L-3 Methods, and +5 to —15 for the Research Method.

Even these conclusions are of limited significance. The road tests discussed were made using a fixed manner of driving and the same test procedure for any particular series of tests. Actually, however, cars are not driven in accordance with any definite procedure and if it were possible to make road tests in accordance with all the manners in which cars are driven, the degree of correlation would be many times poorer than these indications.

WHY THIS WIDE DEVIATION?

This wide deviation of road and laboratory results is due to the fact that the anti-knock performance of a fuel on the road is due in part to the characteristics of the fuel and in equal or perhaps even greater part to the characteristics, condition, and adjustment of the engine in which the fuel is used, and the manner in which that engine is operated. Briefly, some of the engine characteristics which affect detonation of the fuel are as follows:

Spark Timing. This factor alone is probably responsible for much of the deviation. In the old time car the spark advance was controlled by a hand lever; however, this was very inefficient and, in modern cars, the spark advance is controlled automatically. Actually, the spark advance should vary with engine speed, volumetric efficiency, valve timing, engine temperature and several other factors. These variations cannot be obtained within the price limitations of present automobiles, and therefore only two automatic controls are usually used. These are the full throttle maximum power spark-timing mechanism, and the part throttle maximum economy spark-timing mechanism. These two mechanisms cause the spark to vary over wide limits, depending upon speed and throttle opening. Tests on cars show that a difference of 1 degree in basic spark setting affects detonation by an amount which is equivalent to from 1.6 to 2.0 octane numbers in the fuel. When in good mechanical condition, the automatic spark mechanism is accurate to about plus or minus 2°, or the equivalent of from 6.4 to 8.0 octane numbers in the fuel. This is equal to the average difference between regular and premium-grade fuels. In older cars this mechanism usually does not function even this well and, therefore, maladjusted distributors play a vital part in the knocking characteristics of a car and probably far outweigh variations in fuels of the same general classification.

Fuel Distribution. Performance requirements of modern cars require the use of intake manifolds of large cross sectional area and a minimum of mixture heating. Both of these design features are diametrically opposed to good fuel distribution at low speeds when knocking is more prevalent. The result is non-uniform fuel distribution to the various cylinders, both in the amount of fuel and the composition of the fuel. The air and lighter fractions of the fuel are distributed substantially equally to the cylinders. A part of the unvaporized, less volatile portion is distributed fairly uniformly by entrainment with the air, but the quantity of heavy ends so distributed becomes less as engine speed decreases and apparently, at low speeds, a large fraction of the heavy ends are burned in a few cylinders.

The care and accuracy which the refiner puts into the preparation of the fuel is therefore nullified by the separating process which takes place in the intake manifold. Moreover, the octane number of the entire fuel at a mixture ratio for maximum knock has nothing to do with the manner in which the car uses the fuel at low speeds, since it breaks up the fuel into varying fractions and burns these fractions at varying air-fuel ratios. As a result, it is not surprising that two fuels of the same octane number but having different physical characteristics, may perform in an entirely different manner in various cars, and vary from the laboratory octane number by 10 or more units.

Carburetor Setting. The air-fuel ratio supplied by the carburetor is apparently tied into the variation of air-fuel mixtures supplied the various cylinders of multi-cylinder engine. It has been demonstrated that the air-fuel mixtures received by the cylinders vary not only from cylinder to cylinder and from the mixture supplied by the carburetor, but that this variation itself varies with changes in the air-fuel mixture supplied by the carburetor. Moreover, different cars react to such changes in different manners and even cars of the same make and model will not show the same change in anti-knock performance with changes in the carburetor setting.

It appears that fuel characteristics, manifold distribution characteristics, and carburetor air-fuel mixture ratio are inseparately tied together as a part of the detonation problem. Moreover, this relationship varies with different cars and even varies with cars of the same make and model. No generalization can therefore be made except to state that this feature of the automobile engine varies widely its knocking problem.

Compression Ratio and Volumetric Efficiency. It has become the tendency to speak rather loosely of high compression ratios as being responsible for detonation problems. Actually, it is the combination of compression ratio and volumetric efficiency which gives rise to the problem. However, the engine compression ratio which may be used with a given fuel is dependent upon numerous other factors. These are engine design, cylinder size, materials of construction, carbon deposition, engine speed, jacket temperature, mixture ratio, mixture temperature, volumetric efficiency, and ignition

timing. Therefore, the effect of variations in compression ratio can only be considered by simultaneously considering these other variables.

It is a fact, however, that the power output per cubic inch of piston displacement greatly affects the rating which an engine places on a fuel. For example, the 1932 Uniontown tests showed that the best car developed 0.63 horsepower per cubic inch of piston displacement and that this car rated a cracked gasoline higher than the Research Method. Intermediate cars developing 0.49 horsepower per cubic inch rated the same fuel in accordance with the Research Method, cars which developed from 0.49 to 0.29 horsepower per cubic inch rated the fuel approximately in accordance with the Motor Method, and cars developing less than 0.29 horsepower per cubic inch rated such fuels lower than the Motor or A. S. T. M. Method.

Mixture and Jacket Temperature. Increasing mixture or jacket temperatures decrease the apparent anti-knock value of the fuel. However, this change in anti-knock value is not constant for all fuels but depends upon the composition of the fuel. Fuels of natural high anti-knock quality are affected most by temperature changes and therefore the differences in these factors from the conditions of the laboratory test contribute to the deviation of the results.

These features are factors of automobile engine design which work against correlation. However, there are also operating features which do likewise. Such factors are briefly:

OPERATING FEATURES

Carbon and Engine Deposits. Carbon and other engine deposits affect the octane number requirement of a car. It has been shown that, in 12,500 miles of operation, the octane requirement of a car may increase as much as 20 octane numbers with an average effect between 10 and 15 octane numbers. However, there is no assurance that this increase would be the same for all fuels, and indications point out that the degree of correlation is greatly affected by deposits of this type. Changes in engine conditions affect correlation since the response of various fuels to such changes differ with fuel characteristics.

Altitude. Increasing altitude decreases the octane number requirement of cars. However, it also affects the correlation of road and laboratory octane numbers. It has been pointed out that the degree of correlation becomes poorer as the altitude increases, and that these deviations vary for fuels of different types and vary widely for different cars. The question of altitude, therefore, adds to the general confusion as far as correlation is concerned.

Humidity. The effect of humidity on detonation has been studied by several investigators, and their work shows that increased humidity increases the apparent anti-knock value of a fuel. However, this increase is not identical with all fuels but is more pronounced with some fuels than it is with others. Humidity, therefore, also serves to deviate laboratory and road results.

Vapor Losses. The Pawhuska Road Tests made several years ago showed that depending upon the car and the type of driving, as much as 4 percent of the most-volatile and highest-anti-knock constituents of a fuel might be vented from the rear tank and carburetor, decreasing materially the anti-knock value of the fuel actually entering the engine from that originally supplied.

A study of all these factors should convince even the most optimistic that the development of a single laboratory test method for octane numbers which would predict anti-knock performance in cars on the road is impossible. A combination of methods might be developed for better evaluation of fuels. However, for purposes of predicting performance, a method is needed for also evaluating engines since the anti-knock problem is a combined problem of fuels and engines, with the additional complication of the effect of operating conditions.

THE VALUE OF THE OCTANE NUMBER

The laboratory octane number does have a real value, but this actual value exists only to the refiner. If a refiner goes to the trouble and expense of operating a fleet of test cars under a variety of conditions, he can derive an average evaluation of the anti-knock performance of the fuel he is currently manufacturing. After determining the method of processing his particular crude oil to give the actual average car performance desired, the octane number by any method can then be used as one of the control methods for uniformity in quality. If he changes his processing methods, his crude oil, or his proportionate blending of base stocks, the relation of car performance to octane for his gasoline changes and he must again resort to road tests in order to determine the change in road performance and the proper octane number he should now use for control purposes.

On this basis, it matters little whether he uses the A.S.T.M., the L-3, the Research, or any other modification of the octane number test method as the values used apply only to his particular operation.

THE MIS-USE OF THE OCTANE NUMBER

The octane number has not been used in the manner just described. In most instances the refiner and marketer have simply ignored the facts that have been placed before them in published papers on cooperative road tests and by their own technical men. They have acted as though the octane number were an intrinsic characteristic of a gasoline instead of an arbitrary test and as though the maintaining of an octane number level insured uniform anti-knock road performance. The octane number has been included as a sales specification, as a means of establishing price brackets for gasolines, and, in general, over-emphasized. Particularly can over-emphasis be charged against sales promotion based on small octane number differences, which may or may not have been reflected in road performance.

Perhaps there is some measure of excuse for this. The oil companies have been in the middle with pressure being exerted on them from both sides; on the one hand, engine manufacturers have designed their engines to require higher anti-knock gasoline with every new model and, on the other, the motoring public has demanded knock-free operation of its cars. Road testing is expensive, complicated, and even after its completion, requires that the refiner make a decision as to the practical degree of satisfaction he intends to build into his product. On the other hand, the octane-number determination is relatively simple, relatively inexpensive, and the question of complying with some established level of numerical value for octane numbers is, on the surface, a considerably more concrete and perhaps easier question to decide than one relating to the degree of satisfaction that should be built into a product.

RESULTS FROM THE MIS-USE OF THE OCTANE NUMBER

The most apparent result from the mis-use of the octane number has been the so-called octane race. The effort of every refiner to keep the numerical value for

the octane number of his gasoline equal to that of all his competitors has resulted in a steady increase in octane-number values. This, in turn, has meant a corresponding increase in cost to the oil companies with no compensating return. Frequently confusion caused by the existence of more than one laboratory knock-test method has, in itself, inspired fast laps in the race.

Octane number levels have placed unnecessary penalties on some refiners. The refiner whose gasoline performed in a better manner on the road than the octane number indicated, did not actually need the same numerical value for the octane number as his competitor whose gasoline had a poorer road performance than the octane number indicated. Over-emphasis of numerical values cost him unnecessary expense. On the other hand, the refiner whose gasoline performed in a poorer manner on the road than the octane number indicated, has been lulled into a false sense of security by believing his product to be as good as his competitors because the numerical value for the octane number was the same, when he should have been hard at work improving the road performance of his product.

State legislatures have followed along the same lines and have incorporated octane-number limits in state gasoline specifications. This has worked hardships on some oil companies since the octane number may have placed their product in one bracket but actual road performance placed it in a higher bracket. Petroleum research has been directed toward better road antiknock quality in gasoline since this is what is actually desired by the customer. State-established octane brackets based on any laboratory test, therefore, hamper research and conceivably may retard further actual improvements.

The octane number is made to order for that type of advertising which consists principally of the conspicuous posting of big numbers. Since various methods give various results, the proponent of this policy of advertising can use the method which gives the highest numerical values and, by refraining from explaining this detail, make capital of it.

The present confusion which exists in the industry with regard to methods is also a direct result of misusing the octane number.

THE PRESENT SITUATION

The industry is in a state of turmoil due to the fact that not only is a substantial increase in octane levels under way, but it also appears that the L-3 Method is being dropped and that the 1939 Research Method may become the method for commercial transactions. This method is a modification of the old Research Method and is intended to give the same numerical values, but to be more readily reproducible between laboratories than was the case with the older method. Much of the confusion is due to the failure to realize that two separate changes are being made, and that each of them must be given its relative evaluation.

Since the 1939 Research Method gives approximately the same numerical results as the old Research Method, we would expect it to have the same road correlation as that method. In other words, considering all fuels and all cars, it would rate gasolines higher by several octane numbers than the overall road average, but any particular combination of car and fuel might rate a gasoline from 8 octane numbers higher to 11 octane numbers lower than this method.

It is of particular interest to note that the 1939 C.F.R. Research Method is not actually new but is the old Research Method; that is, the very first of the modern knock-test methods, in a new guise. Consequently, the matter of adopting the Research Method has been before the industry ever since 1931. It is, therefore, in order to briefly summarize the history of the Research Method at this juncture.

HISTORY OF RESEARCH METHOD

1931—Method published by Cooperative Fuel Research Committee. Road tests showed cars rated fuels at considerably lower octane-number levels than the laboratory method.

1932—Because the Research Method gave numerical values far too high, the first Uniontown Tests were conducted and the Motor Method was developed by the Cooperative Fuel Research Committee so that average road octane numbers would approximate laboratory octane numbers of average motor fuels.

1933—In spite of the vigorous protests of many refiners, who objected to the lower numerical values, the Motor Method quickly replaced the Research Method. The Motor Method was adopted by the American Society for Testing Materials and is the only knock test method to be so acknowledged.

1934—A second series of Uniontown Tests revealed the fact, long suspected, that the Motor Method did not rate fuels exactly as average cars on the road rated average fuels. The cars said the fuels had slightly higher octane numbers than the Motor Method said they had. But the Research Method was so far removed from the road octane numbers that it was not seriously considered in 1934.

1936-1937—The licensees of Ethyl Gasoline Corporation developed the L-3 Method as a laboratory method which would give numerical values approximately 30 percent of the way from the Motor Method toward the Research Method. It is noteworthy that the objective was to go less than one third of the way toward the Research Method and further that there were a few units in the industry who preferred to adhere to the Motor Method rather than to indulge in a constant changing of knock-test methods which vainly attempted to match the mythical average fuel to the mythical average car, in average condition and adjustment, driven by the average man under the average balance of starting, acceleration, low- and high-speed driving in average weather conditions at the average altitude.

1939—The Cooperative Fuel Research Committee standardized and modernized the old (1931) Research Method and for preciseness called it the 1939 C.F.R. Research Method. The method was developed as a research tool. It is significant that by general consent the method was not forwarded to the American Society for Testing Materials.

Thus, the only thing new about the 1939 Research Method is that, for one reason or another, many more people now know that it results in higher octane numbers. Technically, the situation has not changed in any important respect since the Research Method was first published in 1931. It was then obvious to the entire industry that its numerical values were too far removed from actual performance to be acceptable as a commercial standard. The same facts that existed in 1931 exist in 1940, diminished only to a very slight extent by changes in fuel quality and automotive design. There is, therefore, no technical basis for the use of the Research Method as a commercial standard. Quite the contrary, the same technical bases prevail that have prevailed since 1931 for not using the Research Method as a commercial standard.

The spread of octane number values by various methods depends upon the characteristics of the gasoline. House-brand gasolines are on the market which show a spread between the A.S.T.M. and Research Methods of as high as 8 numbers and as low as 2 numbers. It can readily be seen that the refiner who has a sensitive gasoline with a spread of 8 numbers need only to produce a 72 A.S.T.M. octane gasoline to have also an 80 Research octane gasoline, while the refiner

(*Continued on page 120*)

Removal of Inorganic Salts From Petroleum

CHARLES M. BLAIR, JR.
Tretolite Company

Before the annual meeting of the Western Petroleum Refiners Association, Wichita, April 3, 1940

WITH the adoption of more modern refining equipment and the introduction of new refining processes, the effects of inorganic salts contained as impurities in crude petroleum have become more apparent; and the removal of these impurities prior to refining has become an important problem.

The presence of inorganic salt in crude oil leads to two principal troubles, namely, stoppage of flow or decreased throughput, and corrosion. These, in turn, lead to accelerated coke formation, decreased heat transfer, increased replacement costs, lengthened shut-down time, increased labor requirements, and lowered quality of products.

Speller, in Corrosion, McGraw-Hill, New York, p. 515 (1935), says:

"A few years ago the corrosion losses of the oil refining industry were estimated as equivalent to 1 cent per gallon of gasoline produced. The corrosion problems which are peculiar to this industry arise mainly from the presence of corrosive sulphur compounds (particularly hydrogen sulfide) and of hydrochloric acid from the hydrolysis of magnesium and calcium chlorides in emulsified salt water."

Roberts and collaborators [The Petroleum Engineer, March, p. 42 et seq.; April, p. 144 et seq. (1939)] have studied the hydrolysis of salts in the presence of crude oil and water at temperatures up to 650° F. They found that magnesium chloride is in some cases hydrolyzed to the extent of 90 percent at this temperature and that calcium chloride is in some cases hydrolyzed to the extent of 10 percent. The preliminary hydrolysis of magnesium chloride is postulated to take place as follows:

$$2MgCl_2 + H_2O \longrightarrow Mg_2OCl_2 + 2HCl.$$

This reaction accounts for a 50 percent hydrolysis of magnesium chloride. The basic magnesium chloride resulting from this reaction appears to be able to react with moderately weak organic acids present in some oils to yield further amounts of hydrochloric acid gas, as follows:

$$Mg_2OCl_2 + 4HX \longrightarrow 2MgX_2 + H_2O + 2HCl.$$

This reaction is postulated by Roberts and coworkers to explain the higher percentage of hydrolysis recorded in many cases.

Similar reactions probably take place, but to a lesser extent, with calcium chloride.

SODIUM CHLORIDE

Sodium chloride does not appear to hydrolyze appreciably at temperatures up to 650° F. However, this salt, which is the main constituent of most oil field brines, usually is the cause of plugged heat exchangers, scale formation in lines, and accelerated coke formation.

Some investigators [Puckett, Oil & Gas Journal, 36, No. 19, 44 (1937); Davis, Jones & Nielson, Oil & Gas Journal, 37, No. 2, 62 (1938)] have suggested that the troublesome corrosion of refinery equipment caused by hydrogen sulfide may be greatly lessened by the removal of hydrolyzable salts. These authors suggest that there may be a cooperative action between hydrochloric acid gas and hydrogen sulfide in their action on metal equipment. Ordinarily H_2S will react with iron to form an adherent, protective film of iron sulfide:

$$Fe + H_2S \longrightarrow FeS + H_2.$$

In the presence of HCl this film is supposedly broken by reaction as follows:

$$FeS + 2HCl \longrightarrow FeCl_2 + H_2S,$$

regenerating hydrogen sulfide. In the presence of moisture the ferrous chloride formed may hydrolyze to regenerate HCl. This cycle of reactions can then continue indefinitely, so long as a small amount of HCl is present to initiate it. The net result of these reactions may be looked upon as a reaction between H_2S and iron, catalyzed by HCl. Removal of hydrolyzable salts from sulfur-bearing oils would therefore be expected to result in greatly decreased corrosion.

The presence of inorganic salts in crude oils almost invariably means that the oil contains emulsified brine—or as it is frequently called, "BS." Examination of "BS" under the microscope reveals that it consists of minute droplets of a liquid dispersed in a continuous phase of oil. The dispersed liquid is water or an aqueous solution of salts. Cases have been reported where actual microscopic, cubical crystals of NaCl may be seen dispersed in the oil. The occurrence of solid salt dispersed in crude oil is rare, however. Where solid salt is found in crude oil, it is often due to some treatment received by the oil after its production. Solid salts sometimes result from the evaporation of water from an emulsion which originally contained a concentrated brine. High temperature field treating is often responsible for the occurrence of solid salt in oil.

IN LARGE QUANTITIES

Despite the fact that the salt contained in oils is in the great majority of cases present in the form of

emulsified brine, the amount that can be so held is surprisingly great, even in crudes which show a "BS" content well below pipe line limits. For example, the brine accompanying some Michigan crudes has a specific gravity of 1.21 and a chloride content, calculated as sodium chloride, of about 1200 grams per gallon. An oil containing only 0.5 percent of this brine would have a chloride content (as NaCl) of 550 pounds per 1000 barrels. In other words, a run of 10,000 barrels of such a crude would leave nearly 3 tons of salt in the refinery system. Salt contents as high as this are perhaps unusual, but salt contents of from 100 to 200 pounds per 1000 barrels are common, even with oils having BS & W contents below 0.5 percent.

With an understanding of the manner in which salt is usually carried in crude oil, it is clear that the problem of its removal usually can be solved by removing the last few tenths of a percent of emulsified brine occurring in the oil. In general this may at least theoretically, be done in three ways, namely, mechanically, electrically, and chemically, or by combinations of these methods. No one particular desalting method can be said to be the best or most economical in all cases. Choice of the most economical method for a given oil depends on a number of factors, such as salt content of oil, type of oil, ease of demulsification of brine particles, etc.

MECHANICAL METHODS

The usual mechanical methods of desalting involve sedimentation or filtration, either with or without the addition of fresh water to the oil. Perhaps the oldest and still a common method of separating inorganic impurities is that of sedimentation by settling at an elevated temperature. Frequently fresh water is mixed with the oil before settling to act as a wash to remove brine and salt. Generally this procedure is unsatisfactory since the brine particles originally present in the oil are too small to settle out in a reasonable time even at high temperatures. Also, when fresh water is added as a washing medium, it usually becomes emulsified in the oil to a certain extent due to the stabilizing action of emulsifying agents commonly occurring in petroleum. However, this method does work successfully on certain unusual oils which have little emulsifying tendency and which carry relatively small amounts of salts.

Sedimentation by centrifugal action has been mentioned as a possible method of desalting but apparently has not been used commercially.

The removal of brine by filtration alone, without the use of a chemical demulsifier, is usually a troublesome and expensive operation. On passing an emulsion through a filtering medium such as gravel, hay, excelsior, or the like, some coalescence and separation of brine is usually effected; but in the absence of a chemical demulsifier the stabilized or emulsified brine particles, with their coatings of emulsifying agent, are generally too "water-proof" to be caused to coalesce to any great extent. As a result, salt removal efficiency is small and the filtering medium rapidly becomes clogged with "BS." Filtration or a combination of sedimentation and filtration procedures may be applicable in isolated cases where the oils have little emulsifying tendency. Such oils, however, are the very ones which are likely to be dehydrated most completely in the field to give crudes of low salt content.

The electrical desalting method has proved to have a wide commercial applicability. By choice of proper electrodes, voltage and auxiliary equipment, the electrical process has been applied to a large variety of oils. This method has been described in the literature and at previous meetings of this association, so will not be considered in detail here.

CHEMICAL METHOD

The third general method of desalting is the so-called chemical method, and it is with this method that we shall be mainly concerned in the present discussion. The chemical desalting method involves the use of a chemical demulsifier and is usually combined with a settling or sedimentation stage.

In the application of this method, two main possibilities arise. The crude may be treated with chemical to reduce the already small emulsion content nearly to zero, or fresh water may be dispersed in the oil to coalesce with and drag out the dispersed brine particles through the coalescing action of added chemical demulsifier.

The first, or "superdehydration" method is difficult to apply in practice, since the small percentage of dispersed particles present does not permit rapid flocculation and sedimentation. This method is applicable with certain high-gravity oils where long settling time is available and is identical with ordinary field dehydration except that an effort is made to obtain extremely low BS & W contents in the treated oils.

Some improvement in this process can usually be obtained by a final filtration of the chemically-treated oil through gravel, hay, excelsior, or the like, which effects better coalescence and separation of the small amount of remaining brine.

With any process of demulsification, the rate of separation of the dispersed phase must depend upon the rate of collision of the dispersed particles and upon the rate of settling of these particles in the oil. The 1 percent or less of emulsion contained in refinery stocks almost always consists of extremely fine droplets (often less than 10^{-4} cm, in diameter) which settle very slowly; and since the total concentration of particles is low, the probability of collision and coalescence of particles to form larger droplets which will settle out more rapidly is also very small. The amount of salt removed by this superdehydration method obviously is directly proportional to the decrease in BS & W.

The second process, involving the dispersion of fresh water in the oil, is the one usually employed in refineries. In this case, the amount of dispersed phase in the oil is deliberately increased so that in the subsequent demulsification and settling stages the initial rate of coalescence and settling will be high. The treated oil, after separation of the dispersion, still may have a water content as high as or higher than the original untreated crude; but in this case much of the residual emulsion is composed of the added fresh water. The reduction in salt content with this procedure cannot be measured by the initial and final BS & W contents, since it is dependent upon the amount of fresh water used, the type of dispersion formed, and the relative number of fresh water and brine droplets removed in the dehydration stage.

WATER IN FINE PARTICLES

To get good desalting results with this method, it is necessary that the fresh water be dispersed in the

oil in fine particles so that the probability of their coalescence with brine particles will be high. However, when fresh water is dispersed in crude oils, it becomes, as a rule, more or less permanently emulsified due to the adsorption at the surfaces of the drops of the emulsifying agents commonly occurring in petroleum. For this reason it is necessary to add chemical demulsifiers to the oil or water or to the mixture to overcome this emulsification tendency.

The success of the desalting operation depends greatly on the choice of the proper demulsifying chemical. On first sight it may apepar that the proper demulsifying agent to be used in a desalting plant is the demulsifier which was used to treat the crude down to pipe-line requirements. However, such does not appear to be the case. The choice of a proper chemical demulsifier depends upon the type of oil, the amount and composition of the water phase, the agitation obtainable after addition of the chemical reagent, the settling temperature, the settling space, etc. The relative values of these factors in the refinery are usually different from those in the oil field. Furthermore refinery crude stocks are often composites of crudes from a number of fields, and a chemical demulsifying agent must be found which will work well on this composite material. As the demand for demulsifiers for the desalting process has increased, a number of new reagents have been prepared which are designed to be particularly effective on these refinery emulsions containing a major proportion of salt-free water.

In using the chemical to break the emulsion formed, it may be added at three different points in the process, namely, (1) to the oil before it is emulsified with fresh water; (2) to the fresh water before mixing with the oil; (3) or to the mixture of oil and water. In some cases the demulsifier may be added at more than one of the points. Experience has shown that method (1) is usually the most effective. Chemical is added to the crude charge as far back in the system as is possible, often at the suction of the charge pump. Passing through the pump, the chemical is intimately mixed with the crude and immediately begins its action on the particles of dispersed brine. Later fresh water is dispersed into the oil, and some of the chemical is immediately adsorbed on the surface of these droplets to displace any adsorbed emulsifying agent. The original brine particles by this time have been destabilized by the action of the chemical, and both kinds of droplets are therefore in a condition to begin coalescence.

In explaining the effectiveness of the chemical method of desalting, it does not appear to be necessary to assume that the added fresh water is physically mixed during the dispersing stage with the salt water originally present. Experiments have shown, as a matter of fact, that such physical mixing occurs to only a very small extent. If fresh water containing a dye, such as fluorescein, is emulsified in an oil which already contains some dispersed brine, and the resulting dispersion is then examined under the microscope, it will be found that the proportion of colorless to colored droplets is roughly the same as the proportion of brine originaly present to fresh water added. It seems likely that some of the chemical demulsifier contained in the oil diffuses to the drops of emulsified salt water, and in some manner counteracts the emulsifying agent there segregated, thus increasing the probability of coalescence of these drops with any other drops with which they may come in contact. Then, too, the added fresh water increases the total concentration of particles and, as a result, greatly enhances the probability of collision of particles. These various factors, working together, result in the coalescence of many of the original salt-water droplets with fresh-water particles. Naturally, this process is repeated over and over until the droplets become large enough to settle rapidly and the concentration of dispersed phase falls back to a low value. Optimum conditions for desalting would obtain if, in the dispersion formed, the particles of salt water originally present and the particles of added fresh water all happened to have the same size and the same probability of coalescence on contact with surrounding particles.

NEAR IDEAL CONDITIONS

Under such conditions, with identical initial and final percentages of dispersed aqueous phase, the amount of salt remaining would be directly proportional to the ratio of volume concentration of brine originally present to total volume concentration of brine and fresh water in the dispersion. This ideal condition cannot be reached in practice because of the impossibility of obtaining absolutely homogeneous dispersions and because the droplets of the dispersed brine may be coated with a stable, aged emulsifying layer which prevents as complete destabilization of these droplets by the added chemical reagent as is obtainable with the fresh-water droplets. These later droplets, being freshly formed, appear to be more easily destabilized by the chemical reagent; and as a consequence, the tendency for fresh water particles to coalesce with other fresh water particles is somewhat greater than the tendency for fresh-water particles to coalesce with brine droplets. Although the conditions for optimum desalting cannot be completely reached, they may be approached very closely by proper adjustment of plant variables and correct choice of chemical demulsifier.

Assuming that optimum desalting conditions prevail and knowing the initial salt content of a pipeline oil and the initial and final percentages of aqueous phase, it is a simple matter to calculate the "theoretical" amount of salt left in the oil when a given amount of fresh water is used. The final salt content is given by

$$R = \frac{Sf}{V + i}$$

where S is the initial salt content, f is the final water content, i is the initial water content, and V is the percentage of fresh water (based on the volume of the crude) which is dispersed in the oil.

This equation permits one to estimate approximately the amount of fresh water required to desalt a crude down to any desired final salt content. In actual plant practice, salt removal efficiencies of 85 percent or more of the theoretical value are not uncommon.

In any chemical desalting plant, the throughput obviously is limited only by the time required for the dispersion to settle out. The two principal factors which control this time are the chemical used and the temperature. The nature of the chemical reagent is clearly important, since it determines the rate of coalescence of small drops to form larger ones which settle faster. Temperature is important, since the rate of contact of extremely small particles increases greatly with the temperature in conformity with the laws of Brownian motion. Also, the viscosity of oil decreases with temperature, and the rate of sedimen-

TABLE 1

Orig. Crude		Treated Crude		Percent Fresh Water Used	Settling Time	Actual Percent Salt Removal	Percent Theoret. Salt Removal	Gals. Chemical per 1000 bbls.
BS&W	Salt Content p.t.b.	BS&W	Salt Content p.t.b.					
0.4	193	0.1	20.4	2.4	1 hr.	90	93	2.3
0.4	180	0.1	12.3	2.3	1 hr.	93	97	4.2

TABLE 2

Orig. Crude		Treated Crude		Percent Fresh Water Used	Settling Time	Actual Percent Salt Removal	Percent Theoret. Salt Removal	Gals. Chemical per 1000 bbls.
BS&W	Salt Content p.t.b.	BS&W	Salt Content p.t.b.					
0.5	248	2.6	79	10	2½ hrs.	68	90	0
0.5	250	0.5	22.0	10	2 hrs.	91	96	1.0
0.5	256	0.3	16.1	10	2 hrs.	94	96	1.5

tation of dispersed particles, being inversely proportional to the viscosity of the oil, is consequently increased.

It should be remembered, however, that high rates of contact and high settling rates, alone, do not necessarily lead to successful desalting. The particles which collide or which settle to the bottom of the settler must coalesce or run together to form a clear, separate, aqueous phase which may be drawn off without loss of oil. Where no demulsifier or an improper demulsifier is used, sedimentation of particles often takes place rapidly enough, but they simply stick together with an intervening oil film to form a tenacious sludge rather than a homogeneous separate phase.

PRACTICAL RESULTS

Having considered some of the general principles of chemical desalting, we may now examine some of the practical results which have been obtained in actual plants.

In an average or typical plant, demulsifier is mixed with crude at the charge pump; fresh water is introduced after the oil has been heated through the first exchanger. The water is dispersed in the oil by passing the mixture through a globe valve, giving a pressure drop of 10 to 15 pounds. The mixture then passes through another exchanger and goes into a settling drum having a capacity sufficient to give 1½ hours settling time. Water is drawn continuously from this drum, and clean, desalted oil leaves at the top.

Table 1 gives a summary of conditions and results obtained in a desalting unit which handles about 7500 barrels of oil per day. All figures are averages for a period of 24 hours or longer. Results are given for operation at two different chemical ratios. It should be noted that this plant operates with a very small percentage of water, but nevertheless effects a 90 percent, or better, removal of salt. Incidentally, the crude being handled by this plant is considered relatively difficult to desalt.

Since the desalting system has been installed, unit runs have been greatly increased. At times, crude having a salt content in excess of 500 p.t.b. has been run through the desalting system and into the refining unit without any apparent shortening of on-stream time.

Table 2 gives a summary of results obtained in a unit desalting 16,800 barrels per day. All figures are based on averages over a period of 24 hours or longer.

This plant, among other difficulties, had experienced much trouble with salting up and plugging of heat exchangers. For this reason, the fresh water was introduced before any of the exchangers, and this trouble was almost eliminated. The globe valve was placed between exchangers in order to cause mixing of hot fluids, which appears to lead to more homogeneous dispersions.

WITHOUT DEMULSIFIER

It should be noted that when this desalting plant was operated with no demulsifier being added, the BS & W content of the furnace charge rose to a high figure. This caused a back pressure so great as to necessitate reduction of the charge from 16,800 to about 10,000 barrels per day; and even at this rate, tube pressures were higher than desired. Also, water bled from the settlers at this time was extremely oily; whereas it had been perfectly clear during the desalting operation using chemical.

In Tables 1 and 2, Column 8 gives the percentage of theoretical salt removal based on the initial and final water contents and on the assumption of equal treatability of all dispersed particles. This figure is no measure of actual percentage salt removal, but does indicate to what extent the assumption of equal treatability of particles holds. A high figure indicates that the dispersion formed in the globe valve is fairly homogeneous and that the particles have nearly equal treatabilities. It should be noted in Table 2 that this figure rose appreciably on adding demulsifier to the system although the pressure drop across the globe valve was the same in all cases. This is to be expected when one considers the fact that the demulsifying chemical will destabilize the emulsifying film around the brine particles, thus causing them to approach more nearly the condition of the dispersed fresh-water droplets and thereby leading to nearly equal probabilities of coalescence of salt-water droplets with fresh-water droplets and of coalescence of fresh-water droplets with other fresh-water droplets.

Plant Number 3 operates on about 6000 barrels per day of high-gravity crude with an average BS & W content of 0.4 percent and an average salt content of 155 p.t.b. Fresh water in an amount equal to 5 percent to 6 percent of the crude volume is injected into the cold oil. Chemical demulsifier is fed into this mixture, and the whole is mixed intimately by passing through the charge pump. The mixture then passes through a heat exchanger and into a 500-barrel horizontal settler. The settling temperature is about 220° F. From 1 to 2 gallons of demulsifier are used per 1000 barrels of oil desalted. The crude leaving the settler contains 0.2 percent BS & W and 5 to 12 pounds of salt per 1000 barrels.

In this refinery, as well as in others, slop emulsions are easily handled by continuously injecting them in small amounts into the fresh crude stream. They are then broken by the action of the chemical used for desalting, and the oil contained in them is recovered in a clean, salt-free condition.

The chemical desalting method has definitely established itself as a successful commercial method. As shown by the examples given above, the amount of demulsifier required varies with the type of oil, the salt content, and manner in which the reagent is used. It should be emphasized that the use of a chemical reagent is not alone sufficient for successful removal of salt or brine from crude oil. It must be selected and employed in the proper manner, and its action must be complemented by the installation and operation of a properly designed system.

Thermal Reforming Plus Catalytic Polymerization

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BECAUSE of the upward trend now current in motor-gasoline octane number, there is a desire among refiners to learn something of the process development that will aid them in keeping in step with the octane parade. It is not within the scope of this paper to discuss the reasons for, or even the economic desirability of, the upward anti-knock tendency. We know the situation exists. Accordingly, we are offering the following information in the hope that it will prove of interest and help to the refining industry.

We are attempting to synthesize and pass on to you the best information obtainable concerning one particular process method, namely, thermal reforming of straight-run naphthas, plus catalytic polymerization of gaseous products resulting from reforming.

We feel it is only fair to state that the information contained in the following is based on test results and data furnished by Dr. Gustav Egloff of Universal Oil Products Company.

The method and equipment used in thermal reforming is well known to the refining fraternity. Equally well known is the common weakness of this scheme, namely, that the gas loss is quite large, especially when high-octane gasoline is produced. Catalytic-polymerization plants have become common enough in the last year or two so that they too are known and understood by most refinery men. We will not take your time and ours to describe these units.

By combining thermal reforming with catalytic polymerization, a definite improvement is made, first, in reduction of losses, and, second, in increase in octane number, as compared to the results of straight reforming. We have carefully studied the results of two experimental runs performed in Universal Oil Products Company's laboratories, and are satisfied with the fundamental correctness of the data, and of its applicability to plant operations.

In the first run under consideration, charging stock was a Mid-Continent straight-run naphtha, 53 API, 208° initial, 389°F. end point, and having a 40.5 motor-method octane. This charging stock was reformed thermally with 1000-pound coil pressure and transfer temperatures from 960°F. to 1000°F. Yields by volume and motor method octane, as the temperature was stepped up in 10°F. intervals, was as follows:

Yield percent by Volume	93.0	86.1	82.1	80.1	76.1
API Gravity	56.9	56.8	56.4	56.1	56.2
M.M. Octane	64.5	67.0	68.5	70.0	72.5

End point in all cases approximately 400°F.

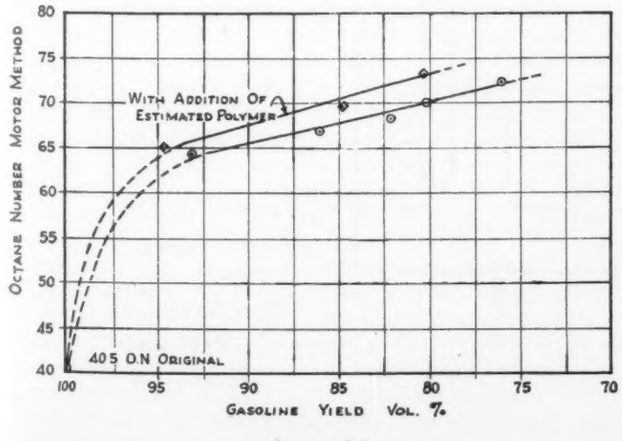
If to the above normal catalytic polymerization product be added the data is as follows:

Yield percent by Volume	94.6	84.9	80.4
M.M. Octane	65	69.5	73.5

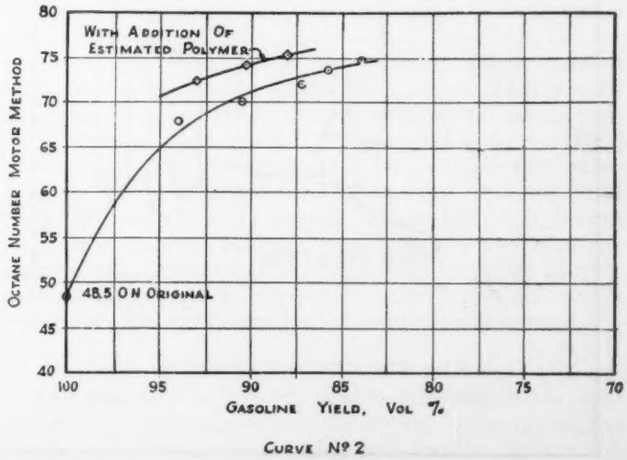
Octane numbers by research method would be from four to eight points higher, the wider discrepancy appearing at the high octane end of the tabe.

In the above tabulation, the improvement due to polymerization of gaseous products resulting from

* Delivered before technical session of the twenty-eighth annual meeting of the Western Petroleum Refiners Association, Wichita, Kansas, March 31, April 1 and 2, 1940.



Curve No 1



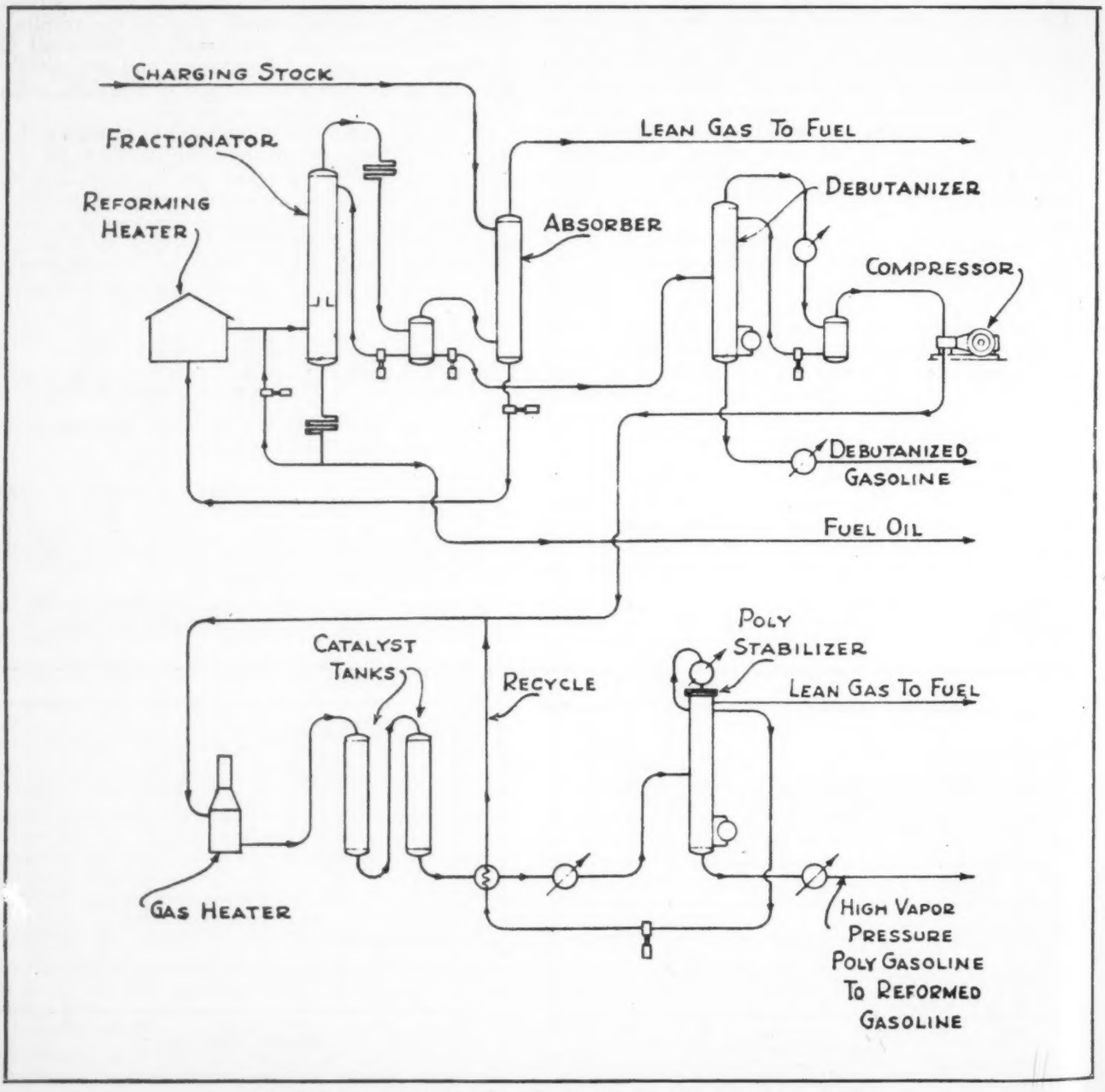
Curve No 2

reforming is not as apparent as when the results are plotted with octane number against gasoline yield. The reason for this is that corresponding figures in the tabulation show improvement in both yield and octane, but the total improvement is not so easily noted. By reference to Curve No. 1, showing the above data graphically, it is apparent that thermal reforming alone will produce a 70-motor-method octane product with an 80 percent yield of product, based on feed volume, while with catalytic polymerization added, a 70-motor-method octane can be produced, with 85 percent yield of product. In short, on an equivalent octane basis, a 5 percent increase in yield, on an equivalent 70 octane, is had by adding polymerization, or conversely, the loss is cut by 5 percent. On the basis of an equivalent yield of, say, 85 percent, the octane may be increased by 2.5 points, with the addition of polymerization.

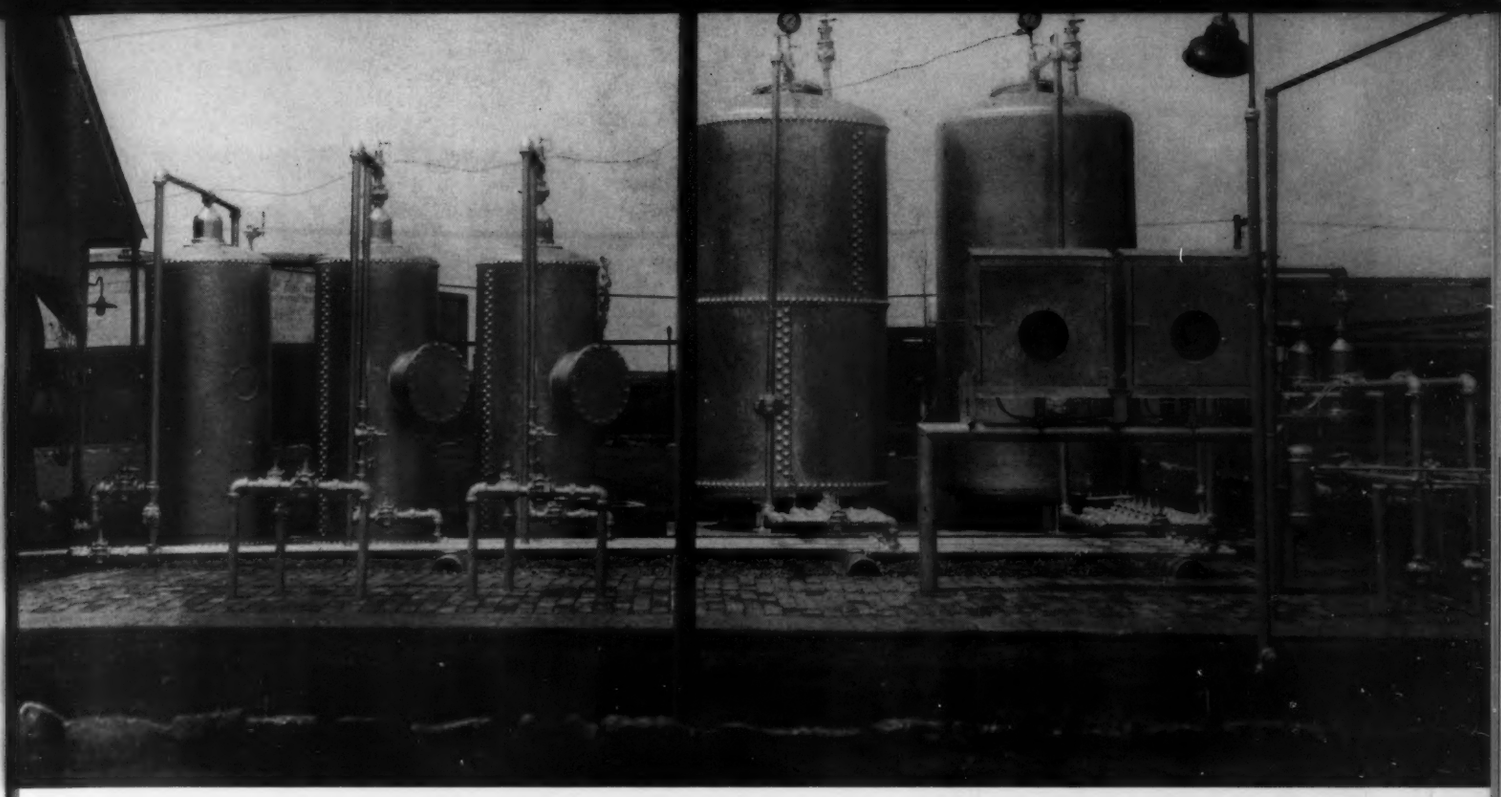
In the second run on which we are reporting, the charging stock was a West Texas straight-run naphtha, having 49.9 API gravity, 191°F. initial, 408°F end point, and motor-method octane of 48.5. Coil pressure was 750 pounds and transfer temperatures 950°F. to 990°F.

Yield percent by Volume.....	94	90.1	87.4	85.6	83.9
API Gravity....	53.9	54.1	53.7	55.2	54.4
M.M. Octane....	68.0	70.0	72	73.5	74.5
Research Oct. ..	75.5	....	....	82.5	83.5

In order to show improvement by polymerizing gaseous products and adding the product to the reformed product, Curve No. 2 is given. Again it will be noted that for a given octane number, about 5 percent more yield (i.e. 5 percent less loss) is encountered when catalytic polymerization is added to thermal reforming, and, of course, it follows that higher octanes can be achieved by adding polymerization than are otherwise possible by thermal reforming.



Flow Diagram of Dubbs Thermal Reforming Unit with Polymerization.



Front view of the two-unit Perco Copper Sweetening Process at the DeNoya plant of Phillips Petroleum Company.

Perco Solid Copper Sweetening Process

SWEETENING gasoline has passed through several transition periods during the past two decades, witnessing the gradual decline of batch treating with acid, the rise of doctor and hypochlorite treating, and recently the development of a system, almost catalytic in action, which involves the utilization of cupric chloride as the reagent, with which both straight-run refined and field-manufactured natural gasolines can be finished in one continuous operation. Even if these gasolines do contain both H_2S and mercaptan sulfur, or any of the different types of mercaptans alone, the arrangement of the Perco Solid Copper Process may easily be changed to suit individual situations. The removal of hydrogen sulfide with a caustic solution ahead of the finishing contact enables a manufacturer of gasoline to use process pressure to produce a product, sweet to the doctor test and negative to the copper strip, in a once-through travel.

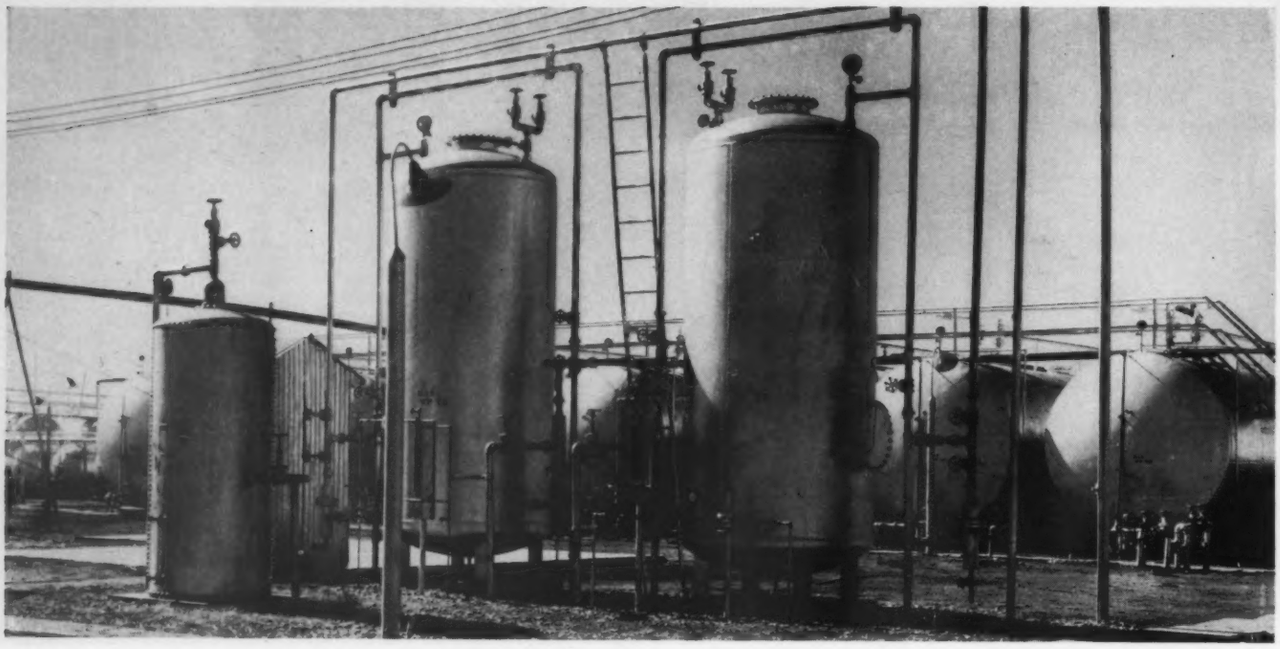
The first Perco Solid Copper treating unit to be placed in commercial operation was in Ector County, West Texas. The natural gasoline manufactured in that gasoline plant contains a high percentage of mercaptan sulfur, difficult to treat with former processes in which sodium plumbite or sodium hypochlorite were involved. Because this extremely sour gasoline was successfully treated, copper sweetening has been adapted to any type of gasoline produced in the Rocky Mountain, Mid-Continent, Gulf Coast and Appalachian regions.

The reagent of the solid copper sweetening process is composed of fuller's earth impregnated with an aqueous solution of cupric chloride. The function of the fuller's earth is only that of a carrier for the cupric chloride solution, and in this form has no value as a treating agent.

While the copper-treating plants in general are similar in construction, they are always engineered for conditions in the plant where they are to be operated for sweetening the product. Two separate engineering lay-outs are followed; one when the commodity contains both hydrogen sulfide and mercaptan sulfur, and the other when the gasoline is free of H_2S, and contains only mercaptans. To sweeten any gasoline, whether straight-run or natural, the material must be free from hydrogen sulfide before it enters the solid copper reagent treating towers. For the elimination of this sulfur compound, a series of vessels and operating equipment are included which utilize an aqueous solution of commercial caustic.

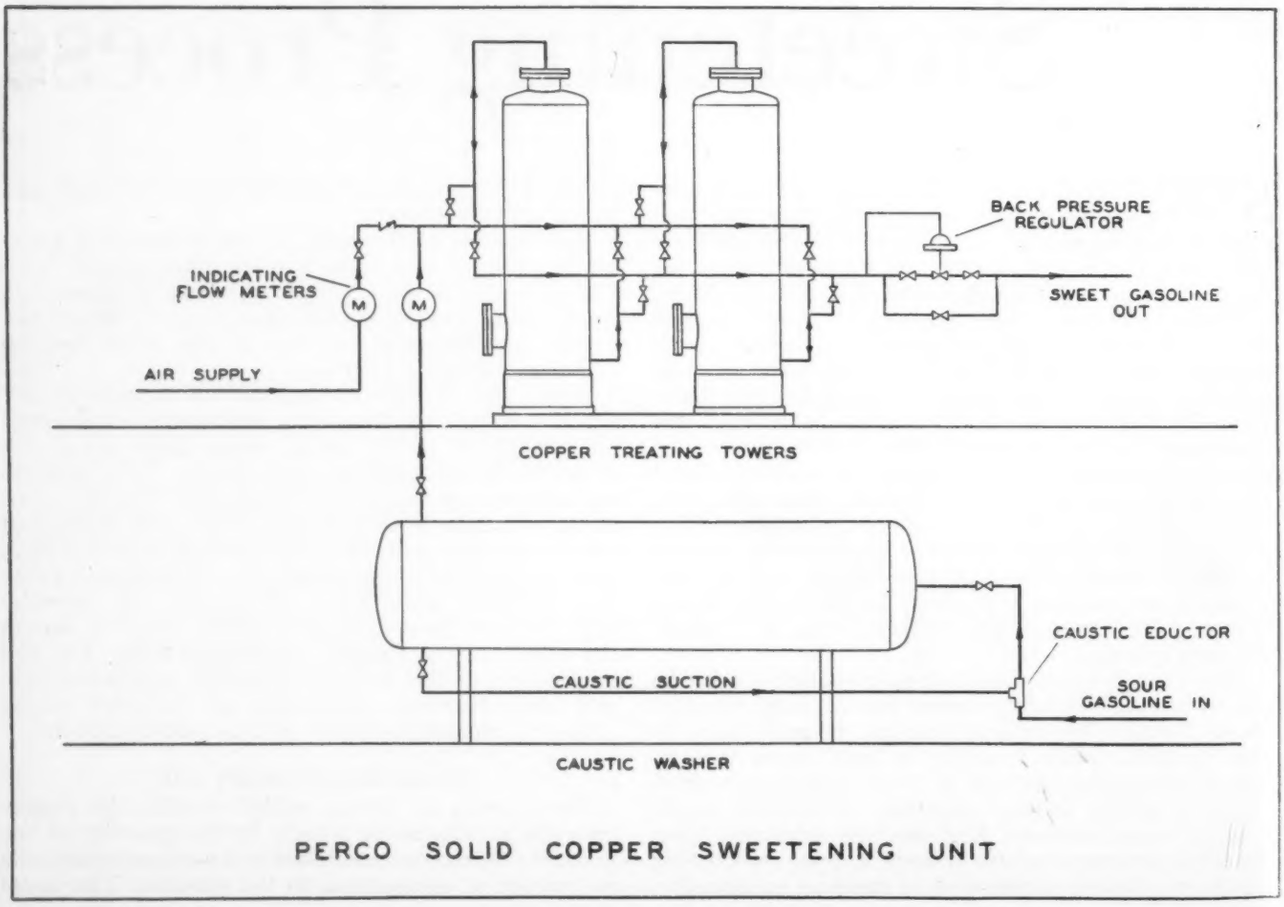
REGENERATION BY AIR

The number of towers which contain the copper chloride is determined laregly by the quantity of the products to be sweetened, and to a smaller extent, the percentage of mercaptans in the gasoline. The usual

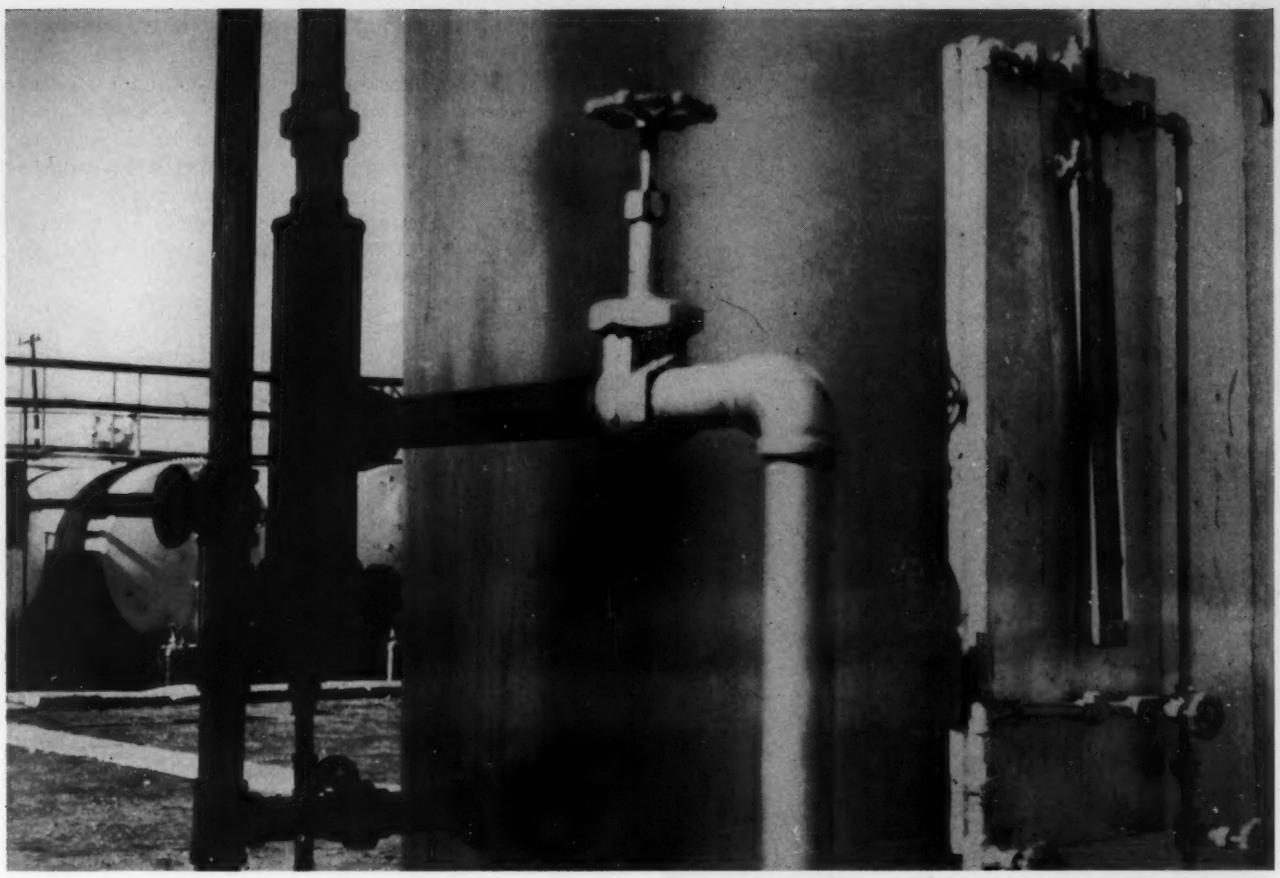


Scrubber at left prevents water entering the reagent bed with gasoline. Lyman, Oklahoma, plant of Skelly Oil Company

recommendation for these treating plants is about one volume of the reagent for two volumes of gasoline per hour throughput. As the reaction in a copper sweetening plant is the formation of cuprous mercaptide and subsequent oxidation to disulfides, a time element must be considered to permit the accompanying reduction of the cupric chloride to cuprous chloride and hydrochloric acid. An almost instantaneous regeneration of the cuprous chloride and hydrochloric acid back to the original cupric chloride is effected with air which is dissolved into the gasoline at a point between the caustic wash—if any—and the copper treating towers. The quantity of air required for the normal reactions within the columns



PERCO SOLID COPPER SWEETENING UNIT



Regeneration of coprous chloride and hydrochloric acid back to cupric chloride is accomplished by introduction of air at a point between the caustic wash, if such is used, and the copper treating towers. Air is introduced through a difussion disc.

is variable, depending upon the percentage of mercaptan sulfur in the sour gasoline. The theoretical amount of air required for adequate sweetening and regeneration is about ½ cubic foot of air per barrel of gasoline for each 0.01 percent of mercaptan sulfur in the untreated product.

Considerable latitude is permitted for the selection of the towers, and many of the plants have been built with vessels which had previously been used for other purposes, but which were of sufficient capacity to contain an adequate quantity of the reagent. In newly constructed copper sweetening plants, the reagent towers are of several different sizes; the size depending upon the amount of gasoline to be treated and the throughput rate. When a gasoline plant is producing less than 500 barrels of stabilized gasoline per day, with only a nominal percentage of mercaptan sulfur, a tower 2 feet in diameter and 10 feet high is considered sufficient. But if a larger quantity of gasoline is being manufactured, towers 3 or 4 feet in diameter and 10 feet high, and possibly installed in multiple, are recommended.

METERING AND PROPORTIONING

The gasoline may be pumped from storage to the treating units, or may be piped directly from the fractionator aftercoolers under process pressure. In any case, the delivery piping terminates in an elevated meter run for measuring the product, and for proportioning the air to the volume of product. In the larger plants, recording proportioning meters are installed on both the commodity and air lines. Where a smaller quantity of gasoline is processed, indicating meters and manual controls are installed.

In operation, the air enters the gasoline through a porous diffuser plate. When proportioning orifice meters are employed, the original setting of the instruments controls the flow of air in the proportion required for optimum reaction in the treating column. As the air passes through the diffusing disc, it is broken into minute bubbles which accelerate dissolving into the gasoline under pressure. The air and gasoline pass from the mixing head to the manifold header to be directed to the treating column desired, to flow from top to bottom or vice versa as the case may be.

If hydrogen sulfide is a contaminating factor in the gasoline, an auxiliary treating plant is installed for the removal of this sulfur compound before the product enters the solid copper sweetening towers. For a gasoline plant which manufactures stabilized natural and butane, or butane-propane mixture, two auxiliary treating plants are constructed for separate treating. Intimate contact between the caustic and the gasoline is obtained by process pressure of the product circulating the caustic from the tank.

To insure complete removal of entrained caustic solution from the gasoline, if any should pass from the settling vessel, a filter is installed between the horizontal settler and the proportioning meter run ahead of the air-gasoline mixing head.

LOW MAINTENANCE

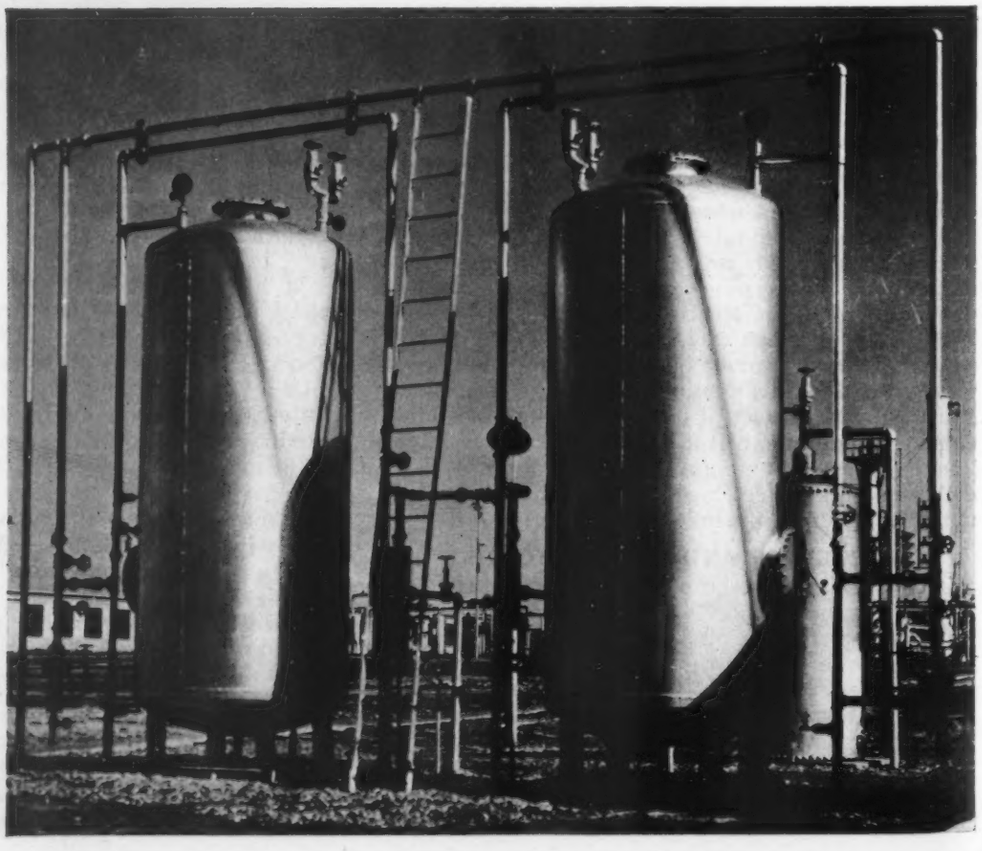
If the copper sweetening plant was designed for a certain maximum volume of gasoline per day throughput, and this amount is increased materially, it is advisable to set an additional reagent tower so that the original gasoline-to-reagent ratio will not

Carry over of the reagent with gasoline is prevented by a small swedge-type flanged-drip scrubber as shown.

be exceeded. Over-loading this type of treating system, as in any other process, will not result in satisfactory treating over long periods. When overloading, the necessary time factor will not be obtained for oxidation of the mercaptans and subsequent regeneration of the reagent without possible displacement of the copper in the bed of reagent.

Maintenance of a solid copper sweetening plant is almost negligible, consisting almost entirely of maintaining the proper ratio of air to gasoline, and preventing the intrusion of excess suspended water, or slugs of water from any source.

The total quantity of gasoline that may be sweetened with a given volume of copper chloride depends upon the sourness of the gasoline, the absence of free water in the product as it enters the columns, the complete elimination of H_2S from the commodity before it enters the columns and the common everyday attention any process should have. A Perco solid copper sweetening plant, used for treating a stabilized natural gasoline produced in Osage County, which contains two towers, each containing about 4900 pounds of reagent has successfully treated over 38,000,000 gallons without the product going sour. Considering only the amount of money expended for the original charge of reagent at 5 cents per pound and assuming that only 900,000 barrels of this gasoline had been treated, the cost would have been $490, or about .0005 cents per barrel total throughput. A large plant in the old Burbank pool using two treating towers to process a butane-free gasoline containing no H_2S has been on stream with the original charge of reagent sufficient time that the reagent cost is now only .0025 cents per 1000 gallons. The time a given amount of reagent will satisfactorily treat gasoline will vary widely, for obvious reasons.



Close-up view of installation at the Lyman plant showing piping.

Caustic contact unit ahead of Universal Oil Products Company copper sweetening plant at Cushing Refinery & Gasoline Company, Cushing, Oklahoma.

Cushing Plant Has New

Copper Treating Unit

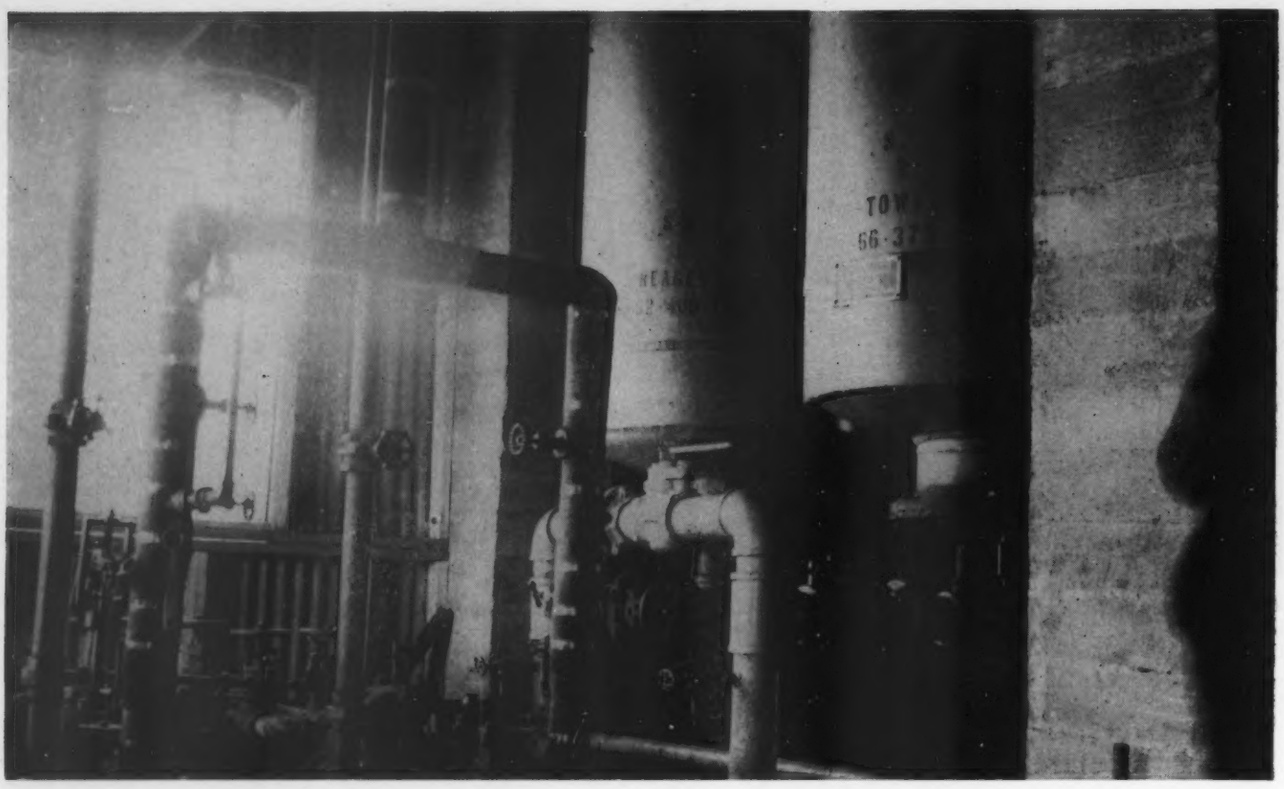
CUSHING Refining & Gasoline Company is among the first to use the improved type of copper sweetening developed by Universal Oil Products Company. Reason for installation of this plant is the sulphur compounds carried by the pressure distillate. Both H_2S and mercaptan sulphur are present in the raw pressure distillate and in the process of stabilization, a large part of the H_2S is removed from the top of the column with excess butane and propane, the remainder being removed with a caustic wash, which also reduces the mercaptan content.

An analysis of the cracked gasoline after stabilization shows the following distribution and volume of mercaptan sulphur:

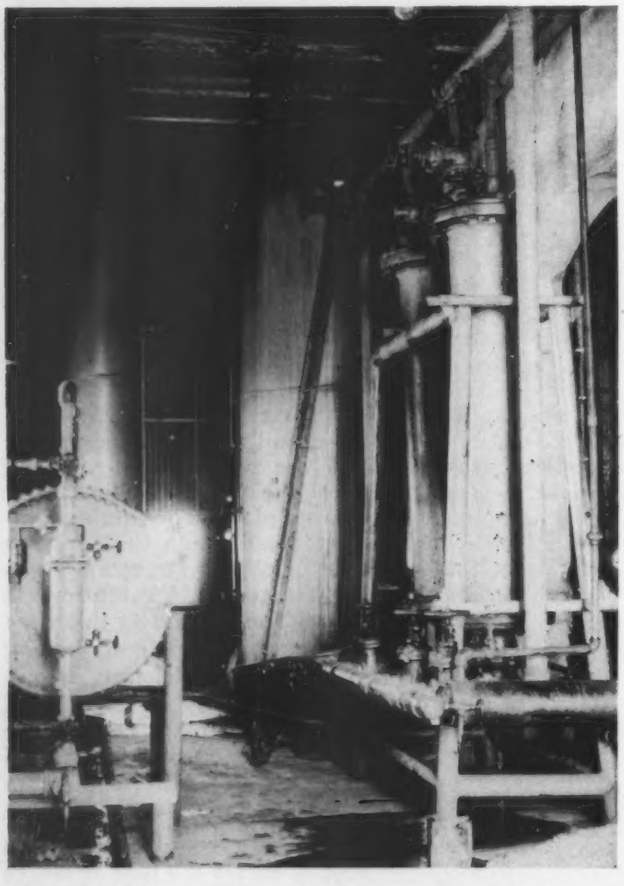
	Percent
Methyl Mercaptans	0.0204
Ethyl Mercaptans	0.0072
Propyl Mercaptans	0.0076
Butyl Mercaptans	0.0038
Amyl Mercaptans	0.0024
Hexyl Mercaptans	0.0026
Total	0.0440

Two separate sweetening systems are operated, both employing cuprous chloride, one for straight-run and the other for the pressure distillate. The straight-run system is divided into two sections, one for 375° F. end point gasoline, and the other for 400° F. end point gasoline. Both the two straight-run cuts and the pressure distillate are washed with caustic before they enter the copper plant. The method employed for contacting the caustic with the pressure distillate at the beginning of copper sweetening was through an eductor, but the resultant mixture was too tight for quick settling. The contact at this time is obtained in a series of two-inch pipe coils having a number of return bends that discharge into a settling tank which has a capacity of six hours. Instruments on the caustic wash plant control the rate of flow of the pressure distillate, which is held to that passing from the stabilizer after-coolers to prevent slugs and sudden surges of gasoline.

As the pressure distillate flows from the settlers in the caustic washing plant, it enters the first vessel of the copper treater containing an aqueous solution of hydrochloric acid to neutralize alkalinity and to re-



Base of straight-run reagent columns, one used to sweeten 375-end-point gasoline and the other a 400-end-point product in Cushing refinery.



Interior of the copper sweetening plant at Cushing Refining & Gasoline Company. Drums at right are acid contactors.

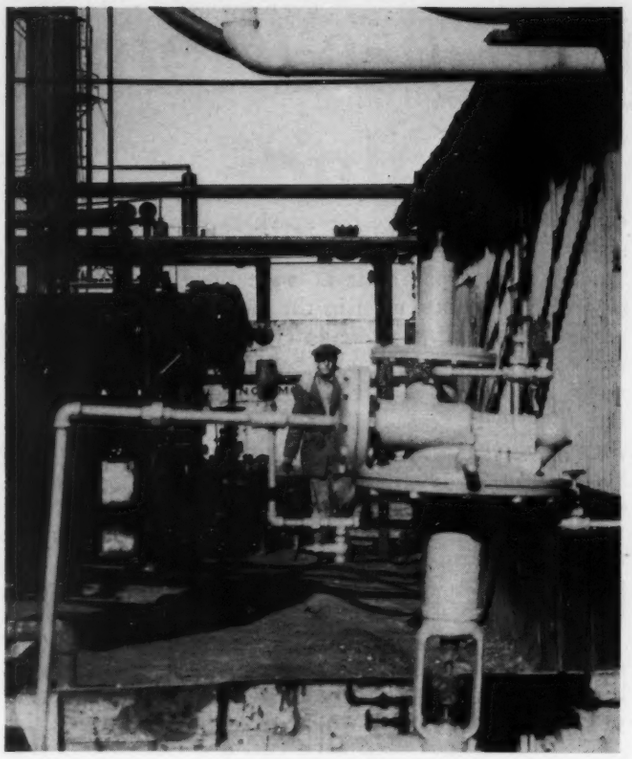
move organic base compounds. If these bases are not removed, they form a brown layer upon the grains of pumice in the copper treating column which neutralizes the hydrochloric acid produced in the sweetening process. Unless hydrochloric acid is present in the treating system, the cuprous chloride is oxidized to copper oxyhydrochloric acid, insoluble in water and of no value as a treating agent.

TWO COLUMNS USED ALTERNATELY

The rate at which the gasoline may be treated with this type of copper sweetening depends upon the type and quantity of mercaptans in the gasoline, but averages between 40 and 50 barrels per hour per ton of reagent. The temperature of the gasoline entering the reagent column is governed by the type and molecular weight of the mercaptans, and for a gasoline such as is produced at Cushing, the temperature is held at approximately 90° F. with steam passing through a jacket around a part of the commodity piping.

Two columns are installed for the first reagent, which is a compound of ammonium chloride and copper sulphate carried in a bed of Italian pumice stone, each column containing about 1000 pounds. The columns are piped so they may be used alternately, one on stream while the other is being reconditioned, reactivated or refilled as the case may be. The water content of the reagent should be maintained between 10 and 15 percent for effective regeneration.

Air to provide the required oxygen for regeneration of the reagent should be about 4 to 5 times the theoretical indicated, and at Cushing the volume is controlled to about 5 cubic feet per barrel of gasoline. A deficiency of air, as well as insufficient



Motor valve which maintains correct pressure on stabilization plant so the product will flow uniformly to copper sweetener

water results in an increase of cuprous chloride which should not be permitted to form a concentration greater than 0.1 percent.

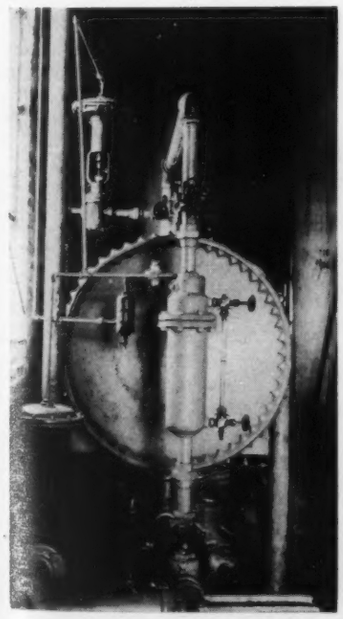
COPPER TREATING PROCEDURE

The gasoline, after contact with the 10° Baume caustic to eliminate the H_2S, flows through the small vessels which contain the acid wash. From the wash columns, the commodity passes through a 3-inch pipe where it is heated by the jacket carrying steam, and immediately thereafter air is introduced in the required volume. Both air and gasoline enter the primary reagent column, from which they pass from an overhead line to a horizontal deaeration vessel where separation of the air is effected. Automatic controls on the vessel maintain a constant flow of gasoline and a constant release of air from the top of the vessel. Gasoline passes directly to the second reagent and the air is vented to the atmosphere.

The second step in the copper sweetening process is with a stabilizing agent composed of zinc sulphide carried on pumice stone which removes traces of copper which may be in solution or mechanically carried over with the gasoline from the first reagent bed because of a deficiency in water content, or a super-saturation. Below 10 percent, the reaction is not sufficient, and above 20 percent may cause a part of the copper to go off in solution and water to be entrained with the gasoline, to contaminate the zinc sulphide.

Under normal operation, the first reagent is regenerated continuously by the injected air. The air, together with the hydrochloric acid produced with the sweetening reaction changes the cuprous chloride to cupric chloride in an oscillating reaction. If conditions are abnormal, the reagent may become supersaturated with water, some of which is precipitated from decomposition of the mercaptans, which will require outside drying of the reagent. In this case, the tower is emptied and the reagent spread over the concrete floor, raked frequently so the air will penetrate the bed which both dries and regenerates the material.

Cost of this type of treating, as compared with the doctor method previously employed at Cushing, is said to be materially lower. At the same time, the octane of the gasoline is not degraded, and has a greater susceptibility to gum inhibitor and tetraethyl lead. The cost, including the pre-caustic wash for the cracked gasoline, is approximately 1 mill per gallon.



A long-range liquid-level controller governs de-aerating drum

Top of the primary treating vessels for cracked gasoline in copper treating process in the refinery at Cushing, showing flanged openings at top for replacing chemicals

Octane Number

(*Continued from page 106*)

with the low spread of 2 numbers would only have a 74 Research value for the same A.S.T.M. value of 72.

The Research Method was intended to be used as an aid in motor fuel and engine research. Apparently its commercial use has been instigated by refiners who had sensitive gasolines in order to take advantage of the possible sales appeal of higher numerical values. Of course, other refiners, in typical fashion and in self defense, immediately followed suit. However, in this case, if no change is made in the basic refining methods, a higher A.S.T.M. octane number is also required, and in the comparison just cited, a 78 A.S.T.M. octane number might be required to meet a Research value of 80. These two gasolines would not give the same road performance at 72 A.S.T.M. octane number, nor do they give the same road performance when both are adjusted to 80 Research octane number. At 72 A.S.T.M., the sensitive gasoline would probably give the best average performance, but at 80 Research the low sensitivity gasoline would fit the greater number of cars. The natural result is that, after this fact becomes apparent, the first refiner would now feel he was forced to make an increase in anti-knock performance and the second would again follow. On this basis, the octane number is truly a will-o'the-wisp, leading from one error to another.

HIGHER OCTANES, WHAT VALUE?

A study of the benefits to be obtained from the use of higher anti-knock value gasoline in present-day cars points out that the benefits are hardly worth the tremendous price which the public must eventually pay. Tests made on 1939 and 1938 model cars show that on the average engine, the spark advance is usually retarded 7° from the point of maximum power. On this setting, the average engine will develop 97.7 percent of its maximum power output. The A.S.T.M. octane number of house-brand gasoline appears to be undergoing an increase of 5 numbers. This means that, with such fuels, the spark may be advanced 3° on the average engine and it may now develop 99.1 percent of its maximum power. This is an increase of 1.4 percent in horsepower output for a 5-octane-number increase in the fuel. When we consider that this increase costs the petroleum industry millions of dollars, the game hardly appears to be worth the candle.

Higher-octane-number gasoline will not diminish knocking complaints but, paradoxically, will increase them. The service manuals issued by the majority of car manufacturers show that the general instructions for adjusting the spark timing for best performance and economy is to advance the spark to the point where a slight "ping" will be experienced under acceleration from 10 miles per hour at wide open throttle, irrespective of the fuel used in the car. Such spark timing adjustments tend to make an engine less and less tolerant to slight maladjustments (such as breaker point wear, engine deposits, etc.) as the octane number of the fuel is increased, thereby increasing rather than decreasing the frequency of knock complaints. On the basis of such spark-adjustment practices, knocking complaints cannot be eliminated by increasing the anti-knock characteristics of motor fuels. The refiner is therefore facing increased trouble from knock complaints and may expect such difficulties to increase as he further increases the anti-knock value of his gasoline.

Automotive engineers have expressed the opinion that the higher-octane-number gasoline now being marketed by oil companies will force them to go to higher compression ratios in their engine design since cars on the road today do not need such fuel and cannot utilize it most efficiently. In fact, automotive engineers do not have available at this time engine designs which give sufficient increase in performance on higher-anti-knock fuels to justify the increased cost of such fuels. We have, therefore, a reversal of former conditions and the oil companies are now setting the pace with engine manufacturers doing no more than trying to utilize the fuels provided.

CONCLUSION

This discussion has attempted to point out that the octane number, in any of its modifications is not a true measure of intrinsic anti-knock quality of fuels. It can never truly correlate with all types of car performance on the road because such performance depends upon engine characteristics and type of operations as much as on fuel characteristics. The oil companies have, therefore, greatly over-emphasized the value of the octane number, and have mis-used it in many ways.

Anti-knock quality in motor fuel is of definite economic value to the consumer. However, present engines do not use this quality most effectively and research indicates that engines could be improved in this respect. In the past, such improvements were not always made, because the refiner lavishly supplied additional anti-knock quality in his fuel to make up for such shortcomings. Only time will tell how much longer he can continue this practice.

Lime Wash Used For Hydrogen Sulphide Removal

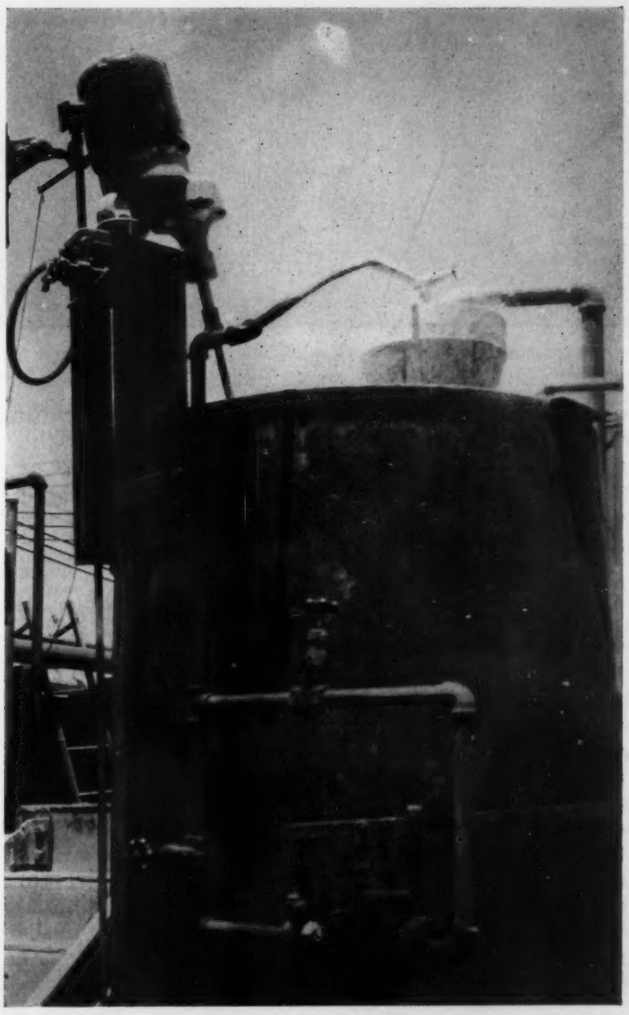
IN revamping its treating system at Big Spring, Texas, Cosden Petroleum Corporation adopted a lime wash for removal of hydrogen sulphide. The change was part of a modernization of the treating system for a plant, which processes 17,000 barrels of West Texas crude oil. Cracked distillate output is around 8,000 barrels daily. Complete plant processes include straight distillation, cracking and reforming.

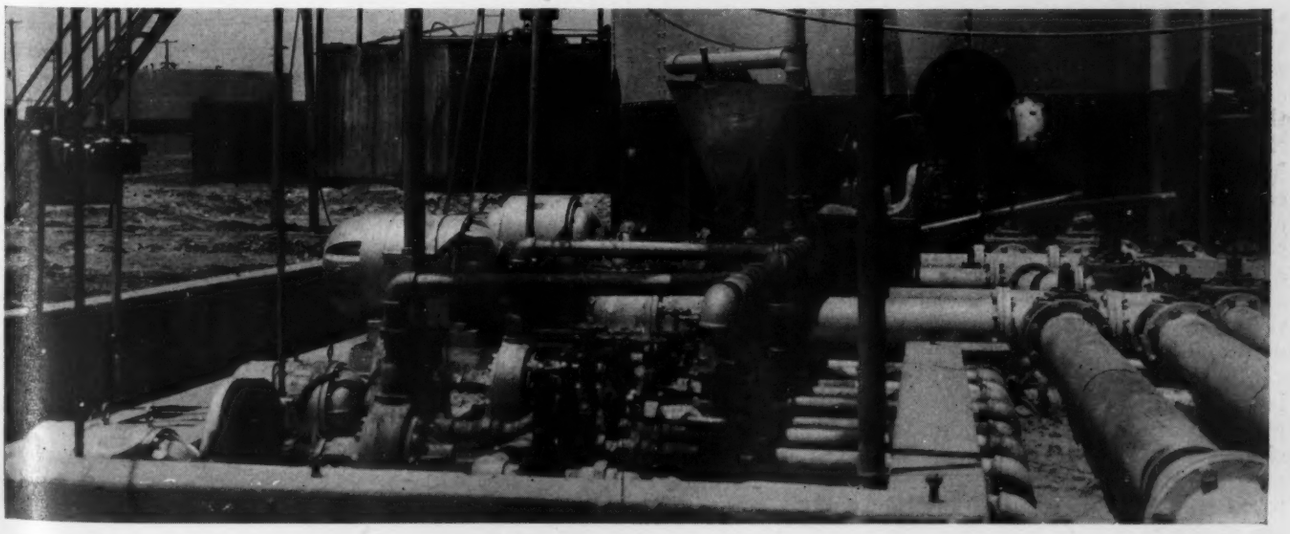
Cracked gasoline and high-octane naphtha both contain undesirable quantities of impurities, which are generally removed with caustic in several stages. The naphtha and cracked gasoline are both stabilized directly from the process receiving drums to reduce the product to the required vapor pressure. The 400-end-point product is passed through exchangers and coolers to reduce the temperature as low as practicable before treating is begun.

First contact in treating this cracked gasoline receives is in a lime wash system to remove hydrogen sulphide. Hydrated lime is used in preference to caustic for several reasons. Among these is that the lime is not poisonous to the skin, and when it is spent, the sludge may be run through the plant sewage system without extra precautions. Another reason is that the H_2S is removed at low cost.

MECHANICAL MIXING

The lime wash used in Big Spring is much more fluid than a slurry, and preparation of the liquid involves dissolving the hydrated lime in water. A cylindrical vessel near the stabilizer is used for pre-





Lime-wash preparation vessels in Cosden Petroleum Corporation's Big Spring refinery treating plant. At right is a portable type mixer. Below is the battery of mixing and contacting pumps. Hopper is for mixing lead with doctor.

Treating transfer pumps shown are centrifugals and are driven by explosion-proof motor units.

paring the lime wash, with an open top and stairs built for accessibility. Hoisting equipment lifts the sacks of hydrated lime to the mixing funnel over tank. A motor-driven, portable type mixer is located at an angle, mounted on a bracket on the side of the mixing vessel.

The mixer is gear driven, which makes it more rigid and permits more strenuous operation. The propellers are three bladed, modified marine form and made of non-corrosive materials. The wash is carried with as high a solution of lime as can be prepared under operating circumstances, and the liquid is contacted directly with the cracked product in mixers and treating vessels.

This wish is recirculated through the treating units until it is spent, after which it is dumped into the sewer. Gasoline containing H_2S as it comes from the stabilizer, passes from the lime-wash contactor free from this type of sulphur compound. A lead acetate test is conducted frequently to determine the thoroughness of the treatment, and consistently indicates a gasoline free from hydrogen sulphide.

READY FOR SWEETENING

The gasoline is run to plant storage after the lime wash, and later finished to sweeten and render non-corrosive. The steps through which the gasoline passes in the subsequent processes after the lime wash are: first, a thorough wash with a 20°Bé. caustic for the removal of a portion of the mercaptans before finishing. The caustic is led to a pump, which also handles the distillate, with both liquids entering a common suction line. The turbulence obtained in the cylinders of the pump form a contact between the solution and the material being treated, and the discharge leads through several cast-iron mixing nozzles to a settling tank. The gasoline is removed continuously from the settler and passed directly to the doctor-solution treating system.

Caustic used for mercaptan removal is regenerated in a continuous system. The caustic is pumped under a pressure of 85 to 90 pounds through heat exchangers to the regenerating system, which is operated at a temperature of 215°F. It is blown with air to liberate the mercaptan sulphur compounds, and receives direct heat from open steam pipes and exchanger heat from closed coils. The caustic solution leaves the regenerator and flows through exchangers, counter-flow to the solution traveling to the regenerator, and finally cooled to 85°F. with water flowing through a closed shell-and-tube unit.

The gasoline, from which about 25 percent of the mercaptans have been removed, flows directly from the caustic wash settling tank to the doctor-treating system; both gasoline and doctor solution being handled with a common pump to obtain the greatest degree of contact before passing on to other equipment. High turbulence, low line friction mixing heads are installed in the transfer lines to thoroughly mix the gasoline with the treating solution. Both pass to a separatory vessel from which the solution is withdrawn at the base, and the gasoline flowing from the top outlet.

The lead sulphide in the doctor solution is recovered and used after the material is passed through a centrifuge for the reclamation of hydrocarbons entrained in the emulsion. The centrifuge is responsible for a salvage of from 40 to 50 barrels of distillate daily, which represents approximately 50 per cent of the charge to the centrifuging unit.

COST REDUCTION

The doctor solution is regenerated in batch vessels, using the most approved method of heating and agitation, continuing the process until the liquid is a clear, dark amber, when it is placed in service again for treating while the batch just withdrawn is regenerated in a similar manner.

The reduction in treating cost after installation of the revamped treating system is quite an item. The NaOH requirement for treating an average of 8,000 barrels of cracked gasoline per day is only 35,000 pounds per month. This amount is less than .13 pounds per barrel of distillate treated, which, when reduced to requirements is only about .00308 pounds per gallon of distillate. The lead for doctor treating is about 1200 pounds monthly, which is only about .0000105 pounds per gallon, showing an extremely high recovery of lead from the treating solution, and a surprising low cost per barrel.

Reduces Time of Regenerating Doctor Solution

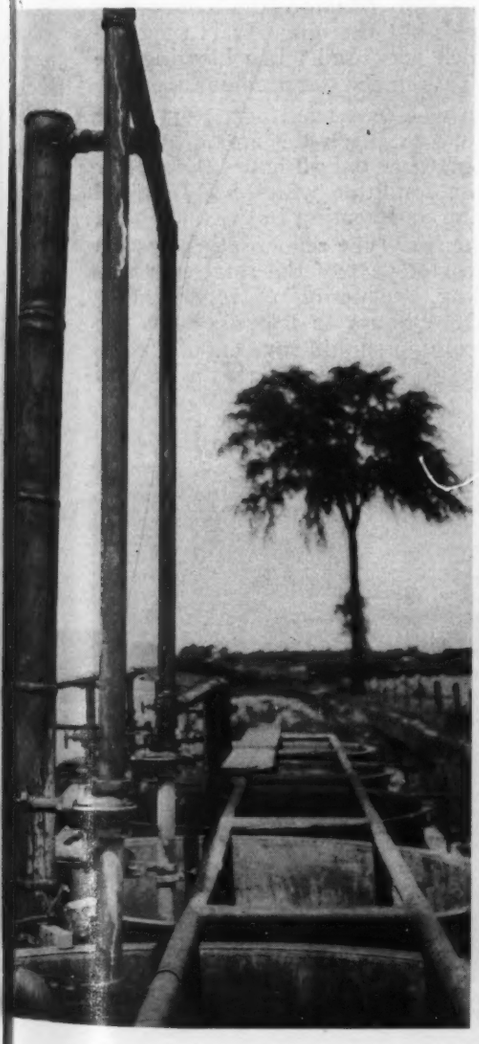
AN effective method has been developed in the plant of Leonard Refineries, Inc., at Alma, Michigan, to reduce the time required when regenerating doctor solution. The results have been satisfactory, and the equipment used is not complicated and requires no more attention by the treater than the method previously used.

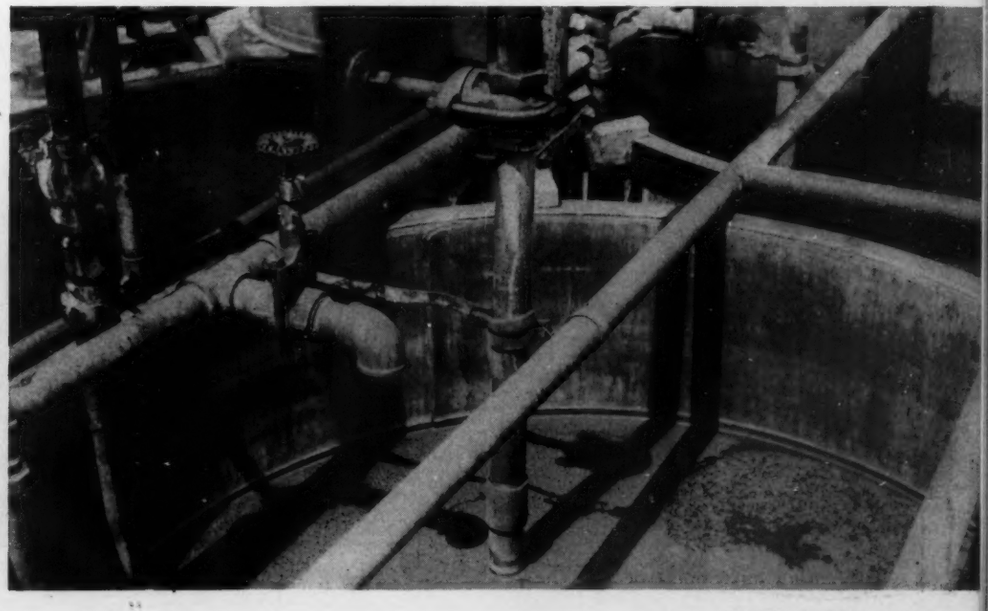
A standard process for regenerating the doctor solution was installed in this refinery when it was built a few years ago, but when the plant was brought up to date and a cracking unit installed, the new system was built. The old system required 24 hours or more to regenerate the doctor. It was pumped from the contacting vessels to open top steel vats which were equipped with steam heating coils and spiders for mixing and blowing with compressed air. The results obtained with the old method were comparable to results obtained in other plants using the same method, and about 20 barrels of doctor solution was used to sweeten about 400 barrels of refined products. When this amount of commodities was treated, the doctor was usually spent and required regeneration. The gravity of the solution was built up to about 23° Beaume at the start of each treat.

Treating of gasoline and other products manufactured at Alma is accomplished in a series of 3 horizontal, all-welded steel vessels placed in the open yard and mounted on concrete cradles, each having an inspection manhole in the end adjacent to the control valves. Lubricated plug valves are used for a positive shut-off for chemicals and commodities, and the intimacy of the mixing between the doctor and the commodity is accelerated with iron mixing nozzles and elbow jets. The mixing nozzles are set in 4-inch pipe, which is reduced at the bottom and at the top to 2-inch; the size of the piping which carries the products and chemicals.

TREATING ROUTINE

The treating plant is designed so the commodity being treated can be given a pre-caustic wash to





At left is side view of doctor solution mixing column in treating plant of Leonard Refineries plant at Alma, Michigan. Below is top of vat for air blowing solution.

reduce some of the sulphur compounds, such as H_2S contacting vessel. The commodity is pumped to the before it enters the mixing nozzles on the doctor-header at the mixing nozzles and flows with the chemical into the vessel, entering through a 2-inch connection near the top of the front head. The chemical settles to the bottom, and the commodity passes through the vessel and leaves through a 2-inch connection a short distance from the rear end at the top of the vessel. Process pressure is sufficient to pass the commodity through the remaining phases of the treating process. Pumps in a near-by building handle the chemicals, drawing them from the base of the vessel and recirculating them through until they are spent.

In a large number of refineries and natural gasoline plants the methods vary, but most follow along several clearly defined lines. Blowing and steaming in open vats until the color is changed to a dark amber and clear without frothing is usually a good indication that the lead sulphate has been regenerated into good doctor solution. The equipment in these plants differ in arrangement and construction, but most have several open top tanks into which the spent doctor is pumped. The vats almost invariably are equipped with steam coils for heating, and have spiders or perforated pipes along the bottom of the tanks so that the compressed air will be mixed as thoroughly as possible.

Plant engineers observed that the reaction of doctor when using compressed air was accelerated by the intimacy of the contact, and the contact more closely made when certain types of contacting apparatus were used. Due to these observations, a specially built contactor and mixing device was made for maximum intimacy between air and doctor solution. The contactor proper was made of a joint of 6-inch pipe, 12 feet long with flat heads welded at both ends to close it. Thirteen alternate slots were cut in this pipe in which baffles were slipped and welded in place. The distance between the inner edge of the baffle and the inside of the pipe is approximately 1½ inches, which provided a "new moon" shape for the orifice. This joint of pipe, which now became a mixing column, was installed between two of the open top steaming and aerating vats which had been installed originally for regenerating the doctor solution.

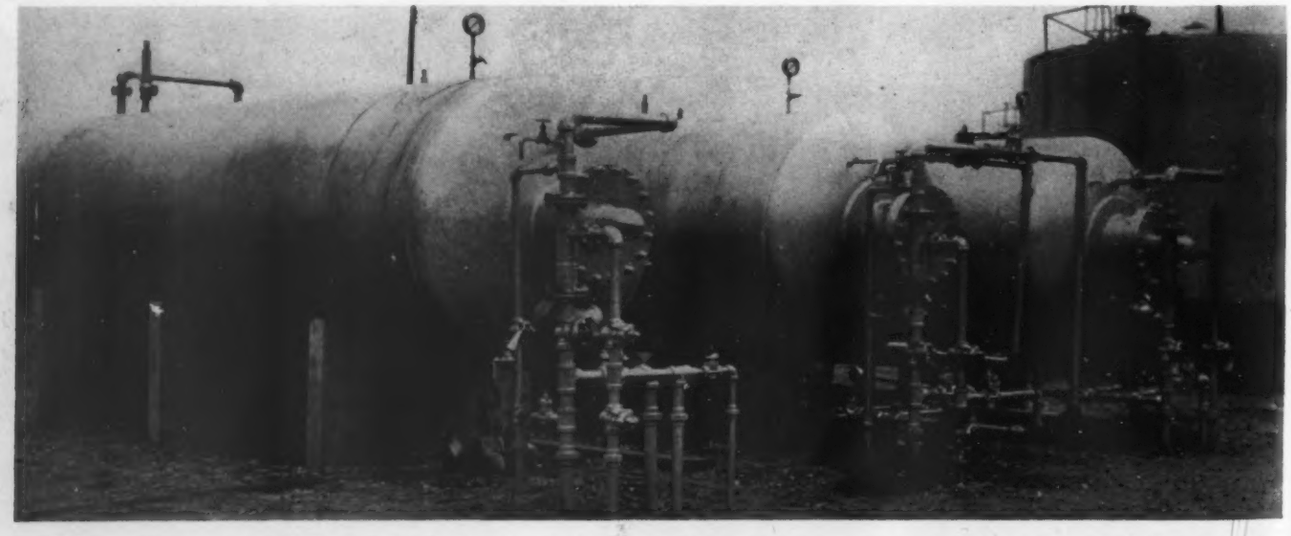
A connection was made in the lower end of this column for the 2-inch transfer pipe from the doctor circulating pumps, and a 1-inch line attached on the opposite side for the introduction of compressed air. A 2-inch collar was welded in the extreme upper end, on the side, for the outlet of doctor and air as they passed through the column. A short nipple with a tee, bull-headed, was fitted to the collar so the outlet pipe would branch in two directions. The horizontal pipe attached to each opening of the tee was measured so that, when an ell on the end, and a vertical riser screwed in, the downcomer thus made would extend well over into the vats on either side. Gate valves, at a convenient height for operating, were placed in each riser, or downcomer, to control the flow of solution as it traveled from the contacting column.

TIME SAVING

When a batch of 20 barrels of doctor has been spent, it is pumped from the contacting and settling vessel to one of the open vats beside the contacting column. The original steam heating coils were left in the vat so that the temperature of the spent doctor could be raised to that required for efficient regeneration. A temperature of about 165° F. is maintained on the batch of doctor while it is pumped from the vat through the contacting column. The amount of air used with the doctor through the contacting column is not metered, but the quantity is approximately the same which was used when blowing the solution in the open vats under the previous method.

When this method was first tried out, tests were made in the laboratory to check the action and behavior of the solution. After only 2 hours the doctor had been changed to a condition which had required 24 hours when blowing and heating in the open vats.

Cost of building the new type regenerating system is nominal, as the greater part of the total cost was for labor and welding. Reduction of regenerating time from the usual 24 hours to 2 hours with the intimate contacting column should save enough compressed air and steam to quickly absorb the cost of construction.



Treating equipment at the Alma plant is in three horizontal vessels in the open yard. This front view shows piping.

Elements of Vaporization and Condensation

Part III. Calculation of Evaporation Losses from Large Atmospheric Storage Tanks

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ALTHOUGH vapor-saving devices and installations have been perfected to a high degree, there is still a large number of atmospheric storage tanks which are not protected in any way from the weather and the consequent loss of lighter gasoline fractions, resulting from the inhalation of air at night, and the exhalation of air and fresh gasoline vapor by day. The use of a light colored paint, such as exterior white or aluminum on the surface of the tank has been found helpful in the reduction of evaporation.[4] The spraying of tank roofs with water is an effective method of preventing excessive losses, since breathing is minimized by the lowering of vapor temperature during the daylight hours.

It is the purpose of this paper to show how approximate vapor losses can be calculated with a meager amount of temperature data. Such calculations are practically required in view of the difficulty encountered in securing accurate measurements of losses by taking tank gages. Furthermore, most large tanks will not withstand pressures sufficient to force the escaping air vapor mixture through an orifice, or positive meter.

Vapor and liquid temperatures are needed in order to estimate the actual breathing which takes place. It is desirable to have recorded temperatures of vapor and liquid over a 24-hour period. If the tank has a 55 or 80 thousand barrel capacity, several temperatures of each phase should be taken so as to make sure that average conditions may be obtained. In spite of convection currents, temperatures are apt to be the warmest near the side of the tank exposed to the sun, and conversely, the coldest temperatures after sunset will be found near the walls and roof.

Vapor temperatures in a tank will often go as high as 30° or 40° F. above the air temperature on clear, sunny days when there is little wind. At night, however, the air and vapor temperatures will tend to approach each other, so that the vapor may be only 2 to 10° F. above the air temperature, early in the morning just before sunrise. The high vapor temperature at noon day, or shortly thereafter, is the result of the conversion of radiant energy, into heat energy on the surface of the tank, which may reach a temperature of 140° to 150° F., some 20 to 30° F. higher than the vapor inside

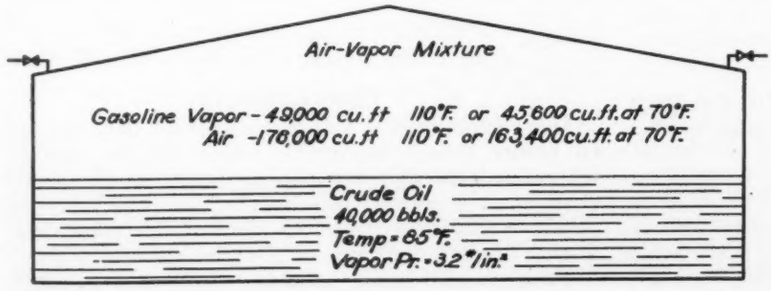
Air-Vapor Mixture
Gasoline Vapor - 49,000 cu.ft 110°F. or 45,600 cu.ft. at 70°F.
Air - 176,000 cu.ft 110°F. or 163,400 cu.ft. at 70°F.
Crude Oil
40,000 bbls.
Temp = 85°F.
Vapor Pr. = 3.2 #/in.²

Figure 1

FIGURE 1

(Left) Conditions existing in a storage tank in hottest part of day.

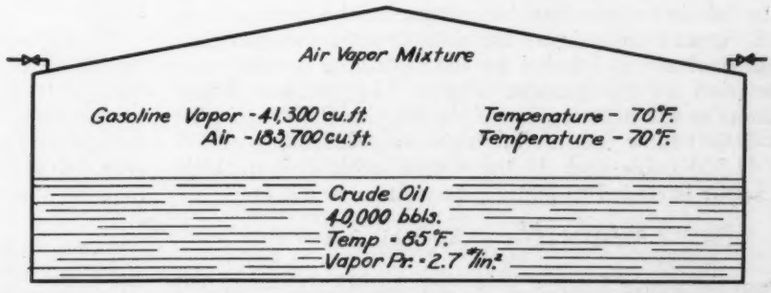

Figure 2

FIGURE 2

(Right) Conditions existing in same tank during coolest part of night.

the tank. The loss of heat, by radiation and convection, from the tank to the cooler surroundings, cannot begin to keep up with the rapid absorption of radiant energy from the sun when it is high in the sky.

The liquid in the tank picks up some radiant energy from the sun through the walls of the tank; however, the far greater mass and heat capacity of the liquid causes this phase to lag behind in temperature change. Consequently, the liquid in a tank may vary only 2 or 3° F. between day and night. Vaporization in the daytime tends to cool the liquid, and condensation of part of the gasoline vapor has a heating effect at night, both of these factors tending to keep the liquid constant in temperature over the 24 hours.

A SIMPLIFIED METHOD OF CALCULATION

The following data are typical of summer conditions in an 80,000-barrel tank, one half full of Mid-Continent crude oil. (Figure 1.)

	Temperatures Degrees F. Minimum	Maximum
Atmosphere	65	90
Vapor Space	70	110
Liquid Space	85	89
Vapor Pressure.....	2.7 lbs./sq. in. abs.	3.2 lbs./sq. in. abs.

It is assumed that equilibrium exists between the vapor space and the crude oil based on the temperature of the latter at all times, and that the average temperatures are arithmetical between the extremes of day and night.

If the absolute pressure in the tank is 14.7 pounds per square inch, the respective partial pressures of air and crude oil vapor will be 11.5 pounds and 3.2 pounds per square inch absolute, respectively, in the hottest part of the day. In the coolest part of the night, the corresponding partial pressures for the air and vapor will be 12.0 and 2.7 pounds per square inch. The volume percentage of vapor is proportional to its partial pressure, therefore the percentage of gasoline vapor in the hottest part of the day will be

$$\frac{3.2}{14.7} \times 100 = 21.80 \text{ per cent}$$

(Figure 1) and the coolest part of the night,

$$\frac{2.7}{14.7} \times 100 = 18.35 \text{ per cent}$$

(Figure 2).

AIR INHALED AT NIGHT

If no condensation took place at night, the shrinkage of the air-vapor mixture could be estimated by the perfect gas law as follows:

Cu. Ft. Vapor Space		Temp. Correction		Cu. Ft. at 70° F.
225,000	×	$\frac{530° \text{ F. abs.}}{570° \text{ F. abs.}}$	=	209,000

225,000 — 209,000 = 16,000 cu. ft. of shrinkage.

This means that 16,000 cubic feet of air at 14.7 pounds per square inch pressure and 70° F. would have to be inhaled to prevent the collapse of the tank.

A further analysis of the data reveals the fact that additional air is inhaled as the result of partial condensation of the gasoline vapor. The gasoline vapor volume in the hottest part of the day is 225,000 × .218 = 49,000 cubic feet and at night only 225,000 × .1835 = 41,300 cubic feet. If the 49,000 cubic feet of 110° F. vapor is cooled to 70° F., its volume would be

$$49{,}000 \times \frac{530}{570} = 45{,}600 \text{ cubic feet}$$

From the above figures, it is seen that 45,600 — 41,300 = 4300 cubic feet of gasoline vapor (at 14.7 pounds and 70° F.) have been condensed. Neglecting changes in the liquid volume in the tank, due to temperature changes and the condensation of part of the gasoline vapor, it is easily seen that 16,000 + 4300 = 20,300 cubic feet of 70° F. air have been inhaled at night.

EXHALATION OF AIR AND GASOLINE VAPOR

During the warming up period for the tank, between dawn and the middle of the afternoon, air and gasoline vapor are exhaled. This "breathing out" is caused by the rise in vapor temperature, and also by the evolution of vapor, resulting from the rising temperature of the crude oil.

The first gas which escapes from the tank in the morning will consist of 18.35 percent gasoline vapor and 81.65 percent air, and by the hottest part of the day the gas will have 21.80 percent gasoline vapor. If the change in the composition of the gas is linear, the average composition of the gas will be 20.075 percent gasoline vapor at an average temperature of 90° F. Since all of the air which was inhaled the night before, will be exhaled, there will be 79.925 volumes of air for every 20.075 volumes of gasoline vapor escape from the tank. There will be

$$20{,}300 \times \frac{550}{530} = 21{,}000 \text{ cubic feet}$$

of 90° air exhaled and along with the air,

$$21{,}000 \times \frac{20.075}{79.925} = 5280 \text{ cubic feet}$$

of 90° F. gasoline vapor. If the gasoline vapor is comparable to that of normal pentane, the liquid volume equivalent to 5,280 cubic feet of 90° F. vapor will be:

$$\frac{5280}{27.7} \times \underbrace{\frac{520}{550}}_{\text{Temp. Correction}} = 180 \text{ gallons}$$

or

$$\frac{180}{42} = 4.28 \text{ barrels}$$

where 27.7 = standard cubic feet of vapor evolved by evaporation of 1 gallon of normal pentane.

This set of calculations has been based on the assumption that the vapor pressure of the crude oil will not fall during the 24-hour period. Actually the vapor pressure of the crude oil will fall from day to day, and likewise the evaporation rate will decline, somewhat rapidly at first and more slowly after a storage period has elapsed.[1, 2, 3]

CONCLUSIONS

More experimental and actual storage data are needed before these evaporation losses can be accurately determined through calculations based on temperature changes. It is entirely possible that the equilibrium temperature may be as near the vapor temperature as it is to that of the liquid, due to a warm surface film.

From the foregoing estimates, it is easy to see that the vapor space above the liquid should be reduced to a minimum in order to prevent excessive breathing losses.

It has been found from experience, however, that breathing losses increase up to liquid outages of approximately 10 percent above which the losses are practically constant. This phenomenon is due to the fact that the air does not mix very readily with the vapor in tanks containing a small amount of liquid since the vapor is usually 2 to 4 times as dense as the atmosphere.

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[2] Lewis, W. K., and Coleman, Stewart P., The Oil and Gas Journal, May 5, 1931.
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Induced
Pyrolysis of Methane

W. J. HESSELS, D. W. van KREVELEN and H. I. WATERMAN

[*Reprinted from the Journal of the Society of Chemical Industry, November, 1939, Vol. LVIII, pp. 323-327*]

THE pyrolysis of methane can be promoted by addition of foreign substances. The substances which show an inductor effect are, *e.g.*, halogens, aliphatic hydrocarbons and hydrocarbon derivatives, such as halogen, sulphur, and oxygen compounds. The inductor effect permits the transformation of methane into ethylene, acetylene, benzene, and naphthalene under such conditions (1170°, contact time 0·06 second) that methane alone passes the heating zone unchanged.

The ratio of methane to inductor in the ingoing gas mixture is of importance. The inductor effect is more marked if the concentration of the inductor molecules is smaller compared with the methane concentration.

FROM investigations of the thermodynamic stability it is known that above 850° abs. methane will tend to decompose into its elements. In the absence of catalysts it is probable that this decomposition will take place by degrees. By greatly decreasing the duration of the reaction it might be possible to limit this decomposition. Fugitive radicals by simultaneous mutual reaction could then enable thermodynamically metastable hydrocarbons to be obtained. Taking into consideration the value of the free energy of formation of different hydrocarbons, it is to be expected that at very high temperatures mainly acetylene will be formed.

Franz Fischer and his collaborators, and also English investigators such as Stanley and Nash and Wheeler and Wood, have indeed realized the formation of ethylene, acetylene, aromatic hydrocarbons, and tar by conducting methane through tubes heated at very high temperature.[1] Under special conditions, viz., using extremely high temperature and short reaction periods, very high yields of acetylene have been obtained.

In some countries the application of the methane pyrolysis for technical purposes has been seriously considered. Fischer in this connection says: "The two processes (the non-catalytic formation of benzene and acetylene respectively by the pyrolysis of methane) have been investigated in a pilot plant of the Ruhrchemie A.-G. Rather good results were obtained. The reason that these processes have not been applied on an industrial scale must chiefly be due to the fact that in Germany there is a lack of large quantities of cheap natural methane."

INDUCED PYROLYSIS OF METHANE

It was therefore considered advisable to investigate how far the process for the pyrolysis of methane could be improved in order to obtain higher yields of valuable products, preferably under milder reaction conditions. It is generally accepted that the decomposition of methane involves the production of free radicals as the primary intermediates. Thus, an endeavor was made to utilize the influence of foreign radicals formed by the decomposition of substances less stable than methane. It was expected that the radicals thus formed would help to a certain extent to decompose methane. The authors indeed have been successful in proving the possibility of an induced decomposition.

Such induced decomposition phenomena are recorded in the literature; metal alkyl compounds have been used for analogous purposes. The radicals formed by the decomposition of these compounds enable the decomposition of hydrocarbons which either would not decompose or would do so to a much smaller extent in the absence of the metal alkyl compounds.[2]

Smith, Grandone, and Rall[3] have stated that the addition of ethane (5-15 percent) can increase the yield of liquid reaction products in the decomposition of methane, although it seems that these investigators have not fully appreciated the significance of the observation.

EXPERIMENTAL

The apparatus used is represented in Figure 1. The reaction tube was a capillary transparent quartz tube with an internal diameter of some millimeters. The method of catching the tar and the benzene formed is indicated in the figure. The gases which still contained unsaturated hydrocarbons were led into flasks filled with bromine, and the volume of residual gases which contained undecomposed methane, hydrogen, nitrogen, and traces of carbon monoxide and dioxide (as contamination) was measured and a gas analysis was made.

In those cases in which chlorine or sulphur compounds were used as inductor, the hydrochloric acid or hydrogen sulfide was trapped in a U-tube filled with soda-lime followed by a second U-tube with calcium chloride.

The contact time (duration of stay in the reaction tube) was calculated as follows:

$$\text{Contact time in seconds} = \frac{a \times 3600\, b}{1000\left(\frac{c}{16} + \frac{d}{m}\right) \times \frac{200}{9} \times \frac{\Theta + 273}{273}}$$

in which $a =$ the capacity in c.c. of the reaction tube in the furnace, $c =$ weight of methane in grams which passes the reaction tube in b hours, $d =$ weight of in-

[1] Fischer, Brennstoff-Chem., 1928, **9**, 309; Fischer and Pichler, *ibid.*, 1932, **13**, 381; Ber., 1938, **71**, [*A*], 56; Wheeler and Wood, Fuel, 1930, **9**, 567; 1928, **7**, 535; Stanley and Nash, J.S.C.I., 9929, **48**, 1 T; Peters and Meyer, Brennstoff-Chem., 1929, **10**, 324; Tropsch and Egloff, Ind. Eng. Chem., 1935, **27**, 1063.

[2] Frey, Ind. Eng. Chem., 1934, **26**, 200; Cramer, J. Amer. Chem. Soc., 1938, **60**, 1406.

[3] U.S. Bureau of Mines, Rept. Invest. No. 3143, 1931.

ductor in grams which passes the reaction tube in b hours, Θ = temperature in °C. of the furnace measured in the middle of the heated reaction tube, but at the outside close to the wall of the tube (it is supposed that the temperature of the whole reaction tube is the same as that measured in the middle), and m = molecular weight of the inductor.

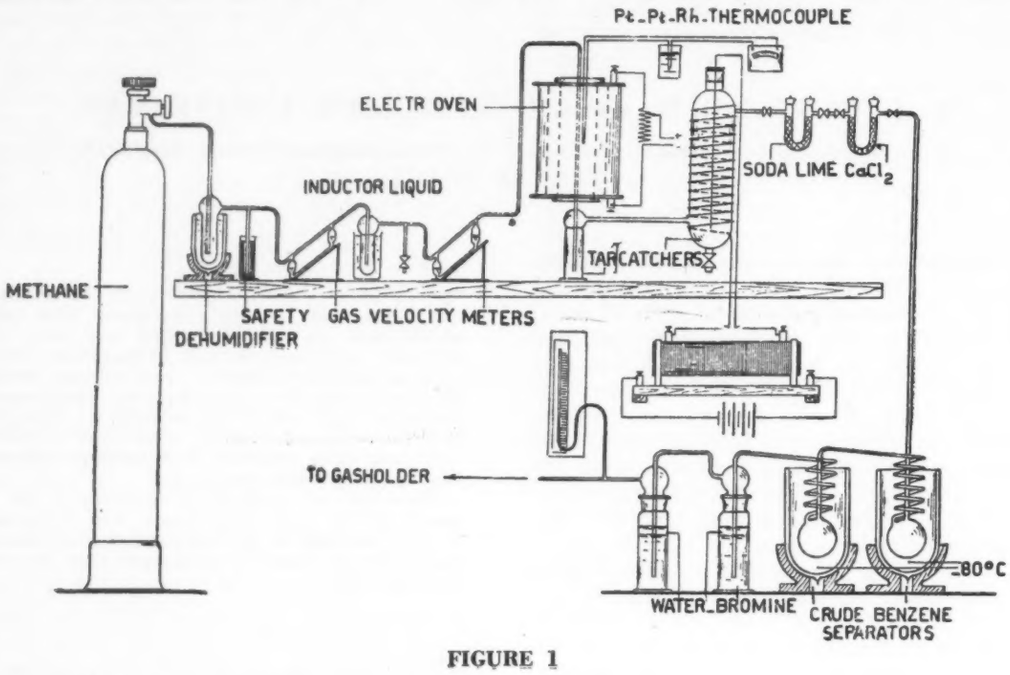

FIGURE 1

Three groups of inductors were chiefly investigated in connection with the methane decomposition: (1) halogens and halogen derivatives, (2) sulphur compounds, (3) hydrocarbons.

In all these experiments we have found a remarkable dilution effect. The greater is the excess of the methane compared with the quantity of inductor introduced, *e.g.*, as chlorine or as a chlorine compound, the more methane is involved in the reaction by an equal quantity of inductor.

In all experiments with chlorine and chlorine compounds the chlorine was quantitatively transformed into hydrogen chloride, hydrocarbons free from chlorine being formed. The sulphur introduced as sulphur compound was partly transformed into hydrogen sulphide, which was bound by the soda-lime, and partly as carbon disulphide, which was trapped together with the benzene by cooling at —80°.

Most of the experiments were carried out at 1170° and a contact time of 0.07 second. Under these conditions methane alone, in the absence of an inductor, does not decompose. If the contact time is prolonged to more than 0.07 second, then the methane begins to decompose. The more this decomposition becomes predominant, the less is the induction effect.

The induction effect and also the dilution effect are illustrated by Figure 2, where the total yield of hydrocarbons from methane, mixed with 1 g.-mol. of inductor, is plotted as a function of the methane-inductor volume ratio. Ethyl chloride was used in these experiments as inductor. The results show that at a volume ratio greater than 14:1, more hydrocarbons are obtained than correspond with the equation $C_2H_5Cl + CH_4 \rightarrow C_3H_8 +$

TABLE 1

Experiments with four successive passages through heated tubes
Temperature 1190°

Experiment No.	1	2	3	4	5	6	7	8	9	10	11	12‡	13‡
Gas	CH_4	CH_4	CH_4	CH_4	CH_4	CH_4	CH_4 C_3H_8 8:1	CH_4 C_3H_8 8:1	CH_4 C_3H_8 8:1	CH_4 C_3H_8 8:1	CH_4 C_3H_8 8:1	N_2 ($C_3H_8+C_4H_{10}$) 8.9:1†	CH_4 ($C_3H_8+C_4H_{10}$) 8.9:1†
Ratio of the volume CH_4 : inductor							0.86	0.86	0.86	0.86	0.86	1.36	0.87
Wt. of 1 litre of gas, in g	0.72	0.72	0.72	0.72	0.72	0.72	224	224	224	224	224	227	230
G. of inductor per cu. m. gas							0.19	0.089	0.062	0.042	0.019	0.066	0.06
Contact time, seconds	0.29	0.19	0.12	0.062	0.055	0.018	63	58	56	47.5	20	14.5	42
Yield of crude benzene* 1	35	27	6	1.5	0.5	0	84	89	89.5	80	38	31	76
after passages 2	75.5	51.5	35	11.5	7.5	2.5	96	110	107	104	59	37	97
3	100	87	60	20	24	4.5	111	128	129	123	73	43.5	110
4	117	110	77	49	41	7.5						‡49	‡125
Yield of tar* 1	30.5	17.5	1.5	0	0	0	190	92.5	59	33.5	3.5	30.5	56
after passages 2	85	59.5	35.5	3	2	0	201	114	83	55.5	9	44	84
3	105	78	61.5	11	7.5	0	205	125	96	74.5	15.5	47	93
4	115	83	71	17.5	13	0.05	207	131	105	79.5	19	48.5	98
												51.5‡	104‡
Total ethylene yield*	18.5	19	19	21	17.5	2	21	28	29	32	72	10	33
Total acetylene yield*	24.5	21.5	34	23	26.5	2	33	48	53.5	59.5	62	41	47
Total methane conversion in % of the original ingoing CH_4	47.5	39.5	34	18.5	17	2	34	26	23	18	4.5	—	19.5

* In g. per cu. m. of original ingoing gas.
† Nitrogen/(propane + butane).
‡ In these experiments five furnaces were used; the temperature was 1170°

HCl. The subdivision of the total yield (tar, crude benzene, ethylene, and acetylene) is also shown graphically.

It is to be expected that not only saturated hydrocarbons (*e.g.*, paraffins) but also unsaturated aliphatic hydrocarbons can serve as inductors for the decomposition of methane. In this decomposition ethylene and acetylene are formed, in addition to tar and benzene.

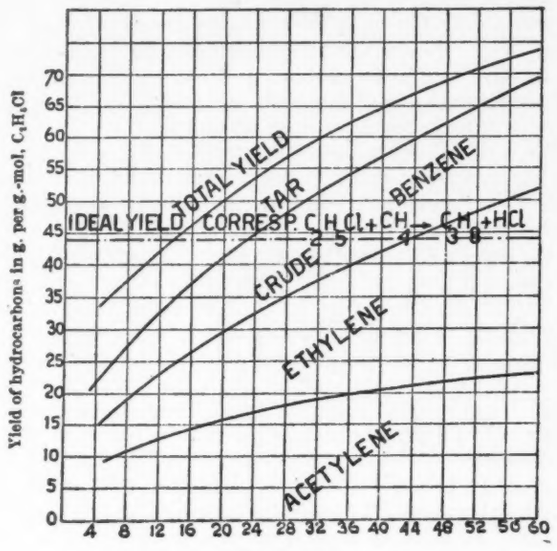
Yield of hydrocarbons in g. per g.-mol. C_4H_9Cl
IDEAL YIELD
TOTAL YIELD
TAR
CRUDE BENZENE
ETHYLENE
ACETYLENE
CORRESP. $C_4H_9Cl + CH_4 = C_5H_8 + HCl$
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70
4 8 12 16 20 24 28 32 36 40 44 48 52 56 60

FIGURE 2
Volume ratio methane : inductor

Ethylene and acetylene have an inductive effect; therefore every methane pyrolysis finally becomes an induced pyrolysis. This will be particularly the case if the gas is passed several times through the tubes in the furnace. After each passage the crude benzene and the tar might be eliminated before the gas is introduced for the next time in the heated tube.

Fischer and his collaborators have applied their process with several passages. With four furnaces at about 1200° they obtained a conversion of 33 percent of the methane introduced into liquid hydrocarbons, viz., 110 g. of crude benzene and 82 g. of tar from 1 cu. m. of methane.

Table 1 summarizes the results of the experiments carried out to compare the yields of benzene, tar, ethylene, and acetylene. The four-passage process was investigated. Two series of experiments were made, the first without the addition of an inductor, whilst in the second series the inductor was introduced in the ingoing original gas. After each passage through the tubes the tar and the benzene were removed before the gas entered the next tube. Experiments 4 and 5 were made without an inductor whilst experiments 8 and 9 are analogous experiments with an inductor (propane).

In experiments Nos. 1-6, the influence of contact time on the non-induced pyrolysis has been studied. Experiments 7-11 show the influence of contact time on the induced pyrolysis.

Experiment No. 12, although not completely comparable with experiments 4 and 9, was carried out with a mixture of nitrogen and butane-propane; it demonstrates clearly the favorable effect of the induced pyrolysis. Although the conditions are somewhat different in this case, yet a comparison of experiments 9 and 13 shows that after five passages at 1170° with the aid of a propane-butane mixture as an inductor, the total yield of crude benzene is about the same as after four passages at 1190° with propane as inductor. Experiment 12 also shows that about 49 g. of benzene have been formed from the propane itself. Therefore, with a contact time of 0.60 second in experiment No. 9 about 129 — 49 = about 80 g. of benzene have been formed from the methane. Methane alone in experiment No. 4 gives only 49 g. Since in the induced pyrolysis one ninth of the volume is originally occupied by the propane, the yield should be multiplied by eight ninths, giving 45 g. The difference, 80 — 45 = 35 g. of benzene, has therefore been formed by the induction.

In Figure 3 the yields of hydrocarbons per cubic meter of ingoing gas are represented graphically as a function of contact time in seconds for the non-induced

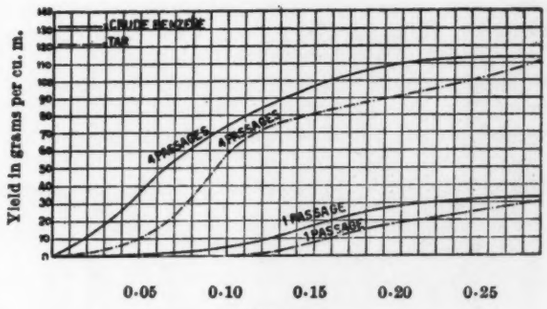

FIGURE 3
Contact time in seconds

methane pyrolysis (Fischer process) and in Figure 4 for the induced methane pyrolysis (the authors' process).

In order to arrive at a proper comparison of both series of experiments, the "capacity" may be expressed as (crude benzene yield in g. per cubic meter of the ingoing gas) ÷ (contact time in seconds). In Table 2 figures for the capacity are given for both processes:

The advantages of the induced process become very obvious if the contact time becomes small, *e.g.*, 0.06 second.

The further the decomposition of methane has proceeded the higher becomes the concentration of hydrogen in the residual gases. After four passages the hydrogen

TABLE 2
Pyrolysis of methane

Contact time in seconds	One Furnace		Two Furnaces		Three Furnaces		Four Furnaces (four passages)	
	Non-Induced	Induced	Non-Induced	Induced	Non-Induced	Induced	Non-Induced	Induced
0.29	120	...	260	....	345	....	400	....
0.19	140	330	270	450	460	510	580	590
0.12	50	...	290	....	500	....	640	....
0.089	...	650	...	1000	....	1230	.....	1440
0.062	25	895	190	1440	320	1730	790	2030
0.055	15	....	140	....	440	....	745	....
0.018/9	0	1050	145	2010	260	3090	420	3850

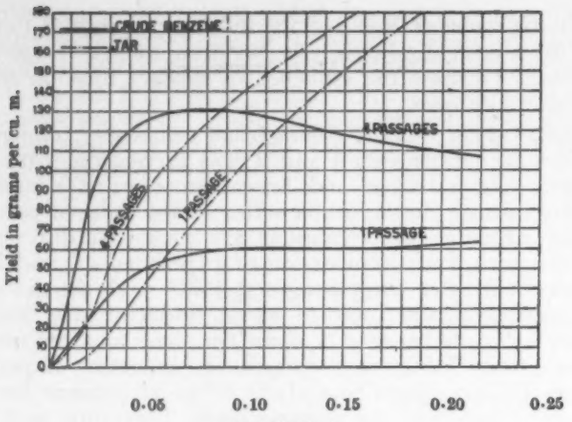

FIGURE 4

Contact time in seconds

content in analogous experiments is already 35-40 percent by volume. In an experiment devised to study the influence of the addition of hydrogen, it was found that this decreases the yields in the induced pyrolysis of methane at 1170° and a contact time of 0.08 second; the benzene and the ethylene yields decrease relatively less than the acetylene and the tar yields.

SUMMARY

In the pyrolysis of methane the primary change is the formation of radicals which react with each other and with the undecomposed methane molecules.

The same radicals can also be formed by the chemical action of, *e.g.*, halogens on methane or by the thermal decomposition of aliphatic hydrocarbon groups which are less stable than methane itself. Hydrocarbons, especially aliphatic hydrocarbons, such as propane, butane, etc., and hydrocarbon derivatives such as halogen and sulphur compounds and oxygen compounds, which are able to split off hydrocarbon radicals, can be used for the production of the radicals necessary to demonstrate the induction effect on the methane pyrolysis.

The inductor effect has been shown without any ambiguity by experiments with pure methane under comparable conditions and also by experiments with the inductor in a pure state in a nitrogen medium.

By applying the inductor effect of foreign substances it has been shown that methane can be transformed into unsaturated hydrocarbons (ethylene, acetylene, benzene, naphthalene) under such conditions that methane alone passes the heating zone unchanged.

The ratio of methane to inductor in the ingoing gas mixture is of importance. The inductor effect is more marked if the concentration of the inductor molecules is smaller compared with the methane concentration.

Aliphatic molecule structures are essential for the inductor action; aromatic compounds such as benzene and naphthalene had very little or no induction effect on the methane pyrolysis in the authors' experiments.

High percentage conversions of methane are observed when the gases are passed through the furnace several times. Unsaturated aliphatic gases formed in the first passage through the heated tube act as inductor in the next passage.

Induced pyrolysis can be applied to methane present in natural gases. These gases contain, in addition to methane, substances capable of acting as inductors.

It has been shown that by the decomposition of the higher hydrocarbons present in natural gas, methane can partly be involved in the decomposition under conditions in which pure methane undergoes no decomposition.

Further details will be described in a thesis of D. W. van Krevelen.

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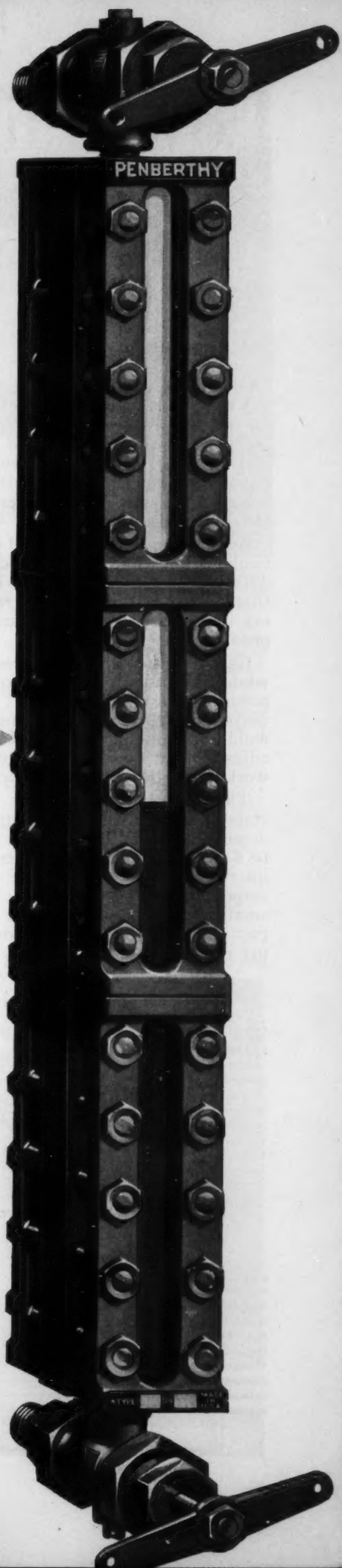


Low Refinery Runs and Proper Yields of Products Needed

L. J. LOGAN

ALTHOUGH the second quarter of 1940 promises to bring for the oil industry an extension of the generally good results of the first quarter, there are several important problems that must be solved satisfactorily to assure stable conditions.

Among the problems, one of particular significance must be dealt with by the refining division. It is that of properly controlling refinery runs and yields of the various products.

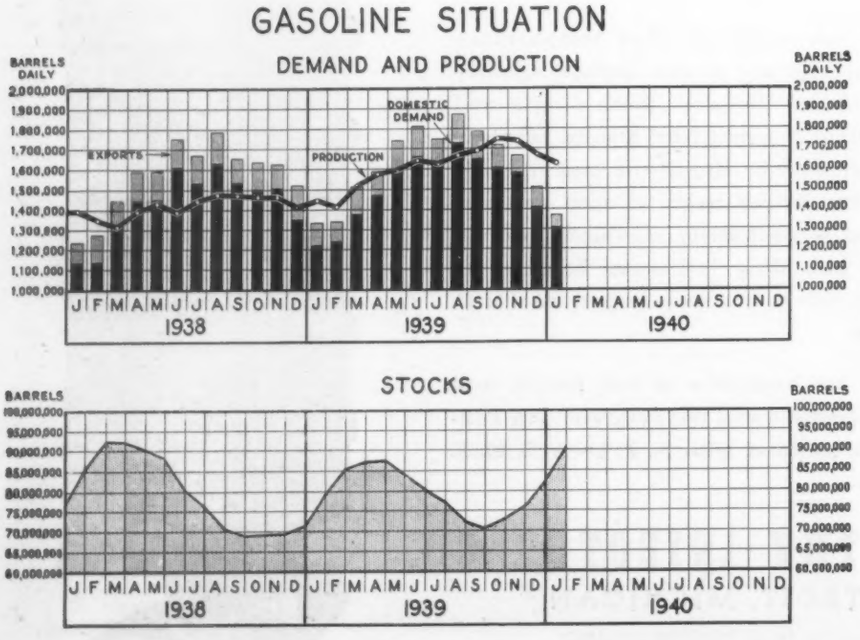
Gasoline stocks are excessive, while inventories of most other products are quite moderate; and during the spring and summer it would be economically desirable to adjust plant operations toward working off the surplus gasoline.

The Bureau of Mines has just stated in its latest forecast that the domestic demand for gasoline may be 6 per cent greater in the second quarter of 1940 than in the corresponding period of 1939, but that smaller exports may reduce the gain in total demand to about 5 per cent.

Gasoline stocks, having risen above 100 million barrels, are more than 13 million barrels above the peak of last spring, however. And the federal agency pointed out that if this seasonal surplus is eliminated during the summer months, it will provide two-thirds of the anticipated increase in total motor fuel demand in the second and third quarters.

To attain a normal balance between supplies of motor fuel and other products, the Bureau of Mines pointed out, lower runs to stills than the current level, with more moderate gasoline yields and higher yields of other products, seem to be essential.

The bureau added that the demand for distillate fuel oil, exaggerated by abnormally cold weather, reached record levels in the first quarter of 1940, but should drop to a more normal level in the second quarter. Nevertheless, the agency stated, in the areas east of California, fuel oil demands in April must be met from current runs to stills because of depleted stocks.


GASOLINE SITUATION
DEMAND AND PRODUCTION
BARRELS DAILY
EXPORTS
DOMESTIC DEMAND
PRODUCTION
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1938
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1938
1939
1940

Having estimated a withdrawal of 1,700,000 barrels from finished gasoline stocks in April, the Bureau of Mines calculated that the fulfillment of current demand for motor fuel would require crude runs of 3,396,700 barrels daily in April, or about 40,000 barrels less than the daily average of 3,436,000 barrels in January, and 93,000 barrels less than the runs of 3,489,000 barrels a day in the four weeks from February 10 to March 9.

The bureau stated further that unless conditions change materially, no substantial increase in runs to stills over the figure forecast for April seems probable for either May or June.

First Quarter Good

The oil industry in the first three months of 1940 encountered remarkably large demand for its products, despite curtailed exports. Meanwhile, inventories have been generally low in relation to the prevailing large demand; and in consequence, prices have been comparatively good, although surplus gasoline has depressed the market for that important product.

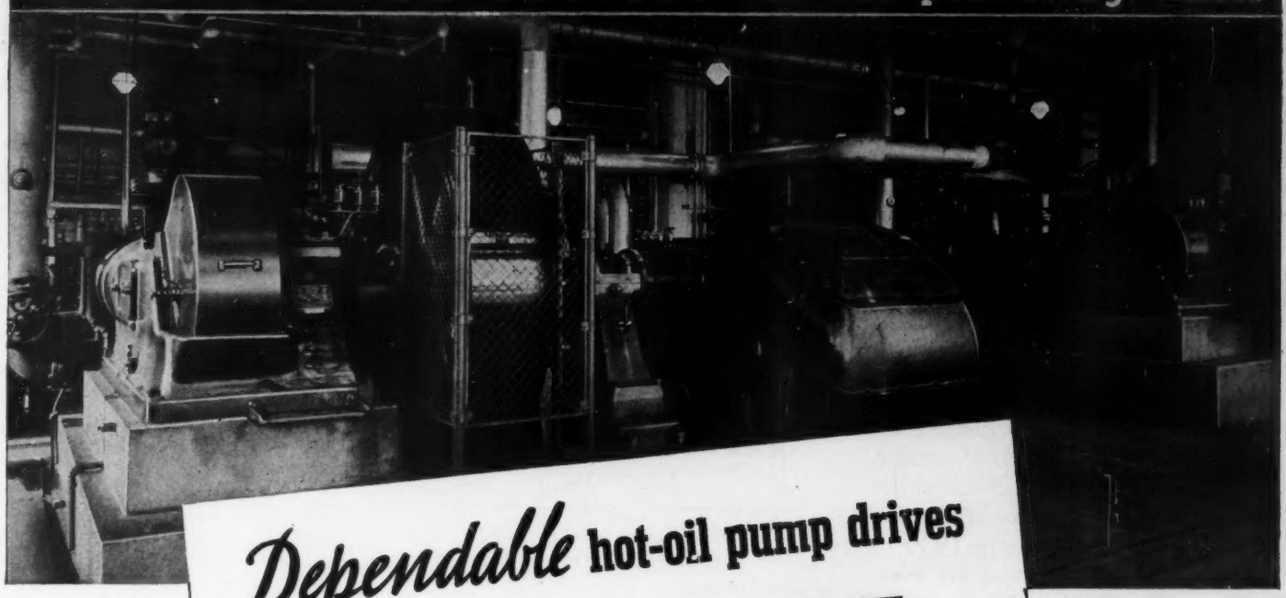
The earning power of the industry has reflected the large volumes of business and the generally good prices, oil companies having earned in the aggregate probably around 25 per cent more in the initial quarter of 1940 than in the corresponding period of 1939. And because of the prospects for continued relatively good business in general and further large demand and favorable prices for oils, it is indicated that the second quarter similarly should be satisfactorily profitable for the petroleum industry.

Demand Is Large

The early months of this year have brought record-breaking demand for nearly all petroleum products.

Because of the European war, exports have lagged. But increases

ELLIOTT STEAM ENGINES for reciprocating units



Two of three Elliott steam engine-driven hot-oil pumps in a mid-western refinery. Engines have hand-operated adjustable cutoff gear to control the engine speed and an enclosed type Pickering overspeed throttling governor driven by a belt.

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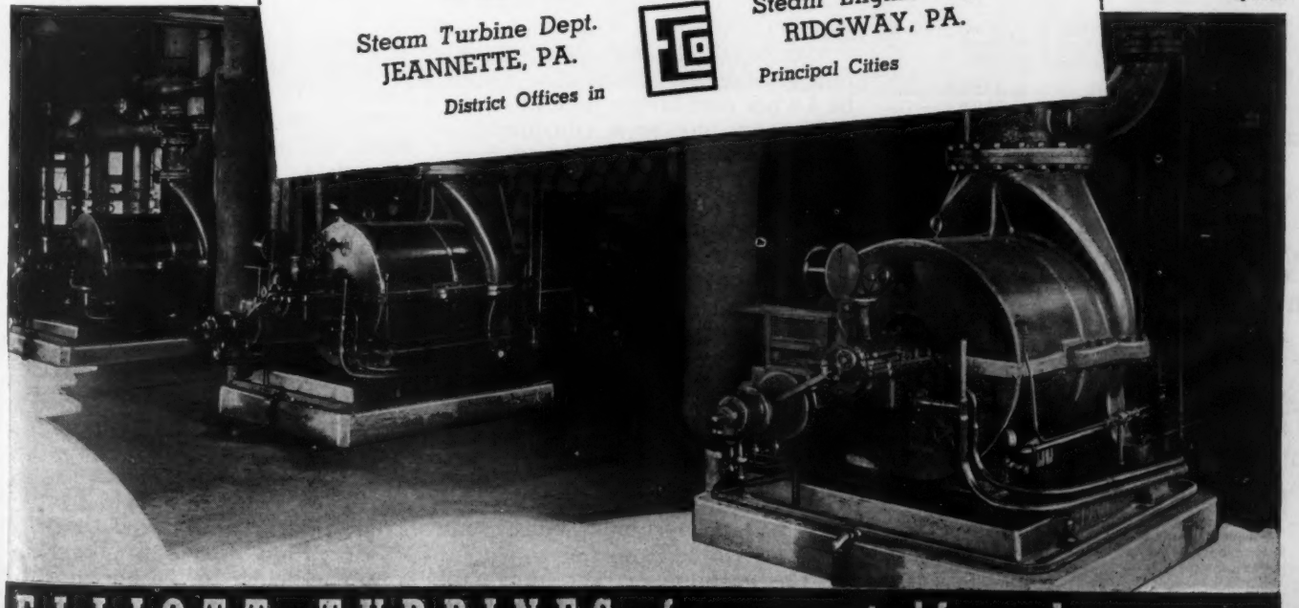


ELLIOTT TURBINES for centrifugal pumps

in domestic consumption have more than compensated for the declines in shipments abroad.

The Bureau of Mines report for January, 1940, revealed that the markets absorbed remarkably large quantities of petroleum and petroleum products in that month.

The total demand for all United States oils was 13.7 per cent greater than in January, 1939.

Total exports were off 17.3 per cent, from 12,971,000 barrels in January, 1939, to 10,728,000 in January, 1940. Crude oil shipments were down only 6.1 per cent, from 4,477,000 to 4,202,000 barrels. But the foreign shipments of refined products in the aggregate were down 23.2 per cent, from 8,494,000 to 6,526,000 barrels.

Total domestic demand was up by the extraordinary margin of 17.8 per cent, having amounted to 115,991,000 barrels in January, 1940, compared with 98,483,000 barrels in January, 1939.

Figures are not yet available on demand in February and March. But it is indicated that both export and domestic demands have continued along the trends that prevailed in January, the former lagging and the latter proceeding at high levels.

Economists of some of the oil companies and oil associations have offered estimates that check closely with the Bureau of Mines opinion that total gasoline demand will be around 5 per cent larger in the second quarter of 1940 than in the similar period of 1939.

For April, the bureau predicted that total motor fuel demand would be 5.6 per cent larger than in April, 1939, with domestic consumption up 8 per cent and exports off from 3,663,000 to 2,800,000 barrels. The indicated large gain in domestic use was based partially on the fact that requirements were abnormally low in April, 1939.

Crude Output Excessive

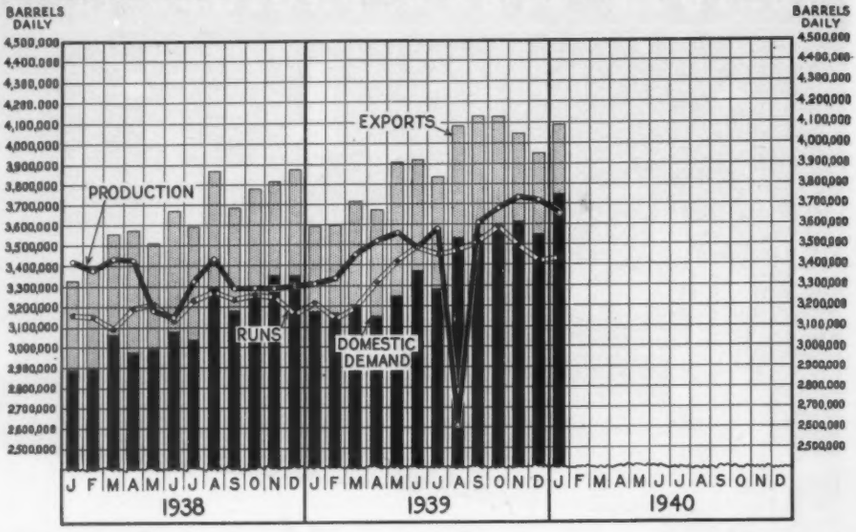
Aside from burdensome gasoline stocks, probably the most important difficulty that the industry has had to contend with lately has been the excessive production of crude oil. Even though the refineries have been running more crude than advisable from the viewpoint of the gasoline market, they still have not processed all turned out at the wells, as evidenced by the recent large additions to crude storage.

Illinois has continued to produce materially more crude than there has been a firm demand for. Some current estimates are that 75,000 barrels of the state's output is being sold for less than posted prices, with prices ranging downward from the $1.05 a barrel posting to as low as 75 cents. Having climbed above 450,000 barrels daily, Illinois production has been exceeding the Bureau of Mines estimates of demand about 125,000 barrels daily, although there is some indication that the bureau figures may be quite conservative.

There is not any prospect that Illinois output will be curbed by proration. But in some quarters it is felt that unless new fields or new pay zones change the picture, production will attain its peak and begin declining before the year's high in petroleum consumption is reached. In fact, some Illinois operators are of the opinion that the state will pass its production peak as early as June, unless unexpected discoveries are made; as the prolific Devonian zone already has been fairly well developed. Nevertheless, it is generally conceded that the actual future of Illinois production is unpredictable—that the output may be bolstered or increased by additional potential oil zones that await exploration.

During March, Texas materially over-produced the Bureau of Mines estimate of demand, under liberalized allowables. But backing up of crude in storage induced the state conservation officials to plan a cutting back close to the bureau forecast in April. And other states of the Mid-Continent also were ex-

DEMAND FOR ALL U.S. OILS - CRUDE OIL PRODUCTION - REFINERY RUNS


BARRELS DAILY
BARRELS DAILY
EXPORTS
PRODUCTION
RUNS
DOMESTIC DEMAND
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1938
1939
1940

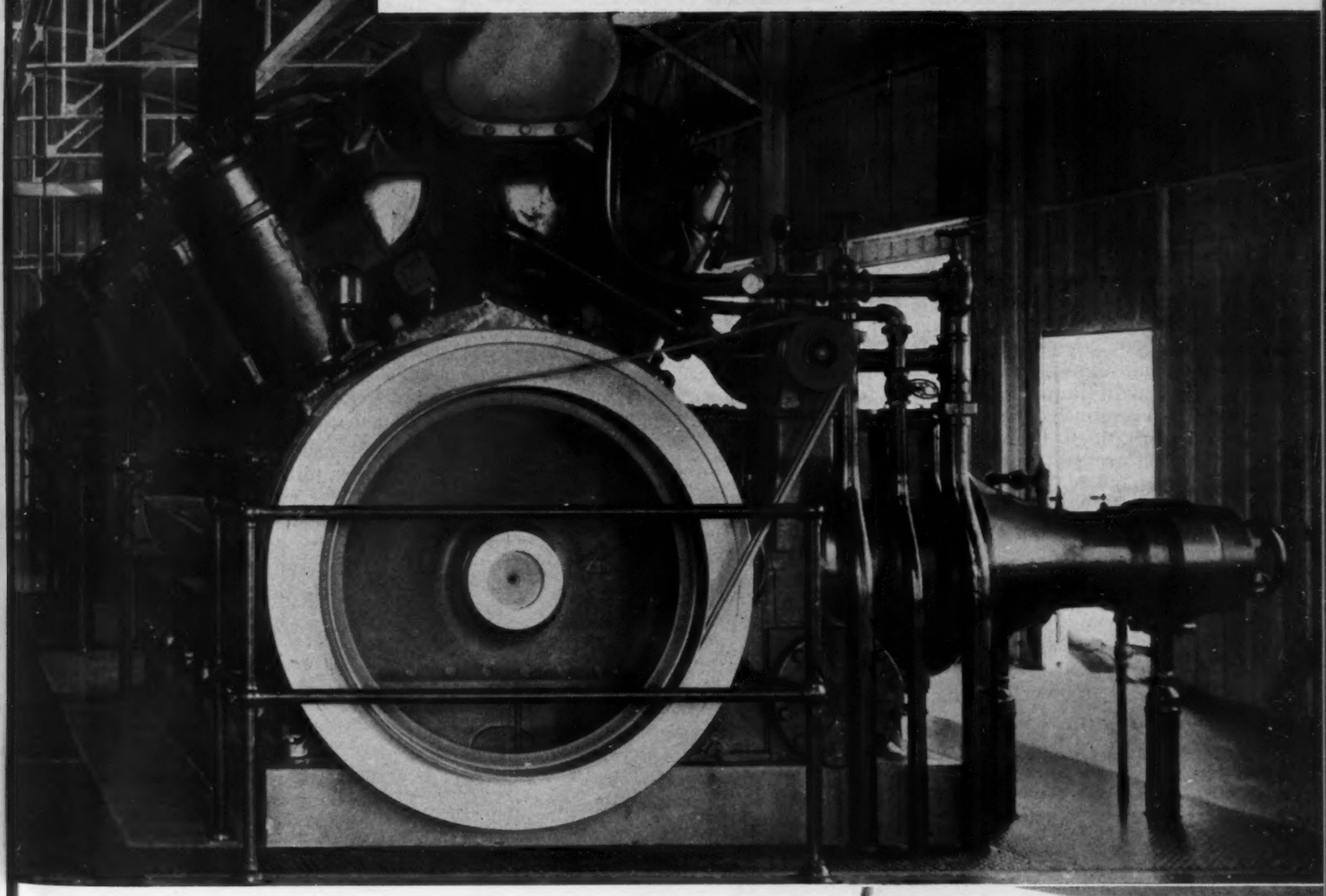
January Oil Demand Sharply Higher in 1940 than in 1939

Figures indicate barrels and are from Bureau of Mines

ITEM	JANUARY 1939	JANUARY 1940	Percent Change
SUMMARY—			
Tota Demand	111,454,000	126,719,000	+ 13.7
Daily average	3,595,000	4,088,000	+ 13.7
Exports:			
Crude petroleum	4,477,000	4,202,000	— 6.1
Refined products	8,494,000	6,526,000	— 23.2
Total exports	12,971,000	10,728,000	— 17.3
Domestic Demand:			
Total domestic demand	98,483,000	115,991,000	+ 17.8
Daily average	3,177,000	3,742,000	+ 17.8
TOTAL DEMAND FOR PRODUCTS			
Motor Fuel:			
Domestic	37,767,000	40,370,000	+ 6.9
[1]Exports	3,638,000	2,274,000	— 37.5
Total	41,405,000	42,644,000	+ 3.0
Aviation Gasoline (included above):			
Domestic	[4]	554,000	[4]
Exports	553,000	155,000	— 72.1
Total	553,000	709,000	[4]
Kerosene:			
Domestic	5,980,000	7,842,000	+ 31.1
Exports	810,000	191,000	— 76.4
Total	6,790,000	8,033,000	+ 18.3
Gas Oil and Distillate Fuels:			
[2]Domestic	16,963,000	22,787,000	+ 34.3
Exports	1,675,000	1,549,000	— 7.5
Total	18,638,000	24,336,000	+ 30.6
Residual Fuel Oils:			
[2]Domestic	28,443,000	32,148,000	+ 13.0
Exports	1,379,000	1,139,000	— 17.4
Total	29,822,000	33,287,000	+ 11.6
Lubricants:			
Domestic	1,609,000	2,054,000	+ 27.7
Exports	851,000	1,068,000	+ 25.5
Total	2,460,000	3,122,000	+ 26.9
Wax (thousands of pounds):			
Domestic	20,642,000	35,187,000	+ 70.5
Exports	18,342,000	21,142,000	+ 15.3
Total	38,984,000	56,329,000	+ 44.5
Coke (short tons):			
Domestic	106,000,000	137,800,000	+ 30.0
Exports	10,500,000	16,600,000	+ 58.1
Total	116,500,000	154,400,000	+ 32.5
Asphalt (short tons):			
Domestic	192,900,000	149,500,000	— 22.5
[3]Exports	3,300,000	19,300,000	+484.8
Total	196,200,000	168,800,000	— 13.9
Road Oil:			
Domestic	173,000	132,000	— 23.7
Miscellaneous:			
Domestic	173,000	240,000	+ 38.7
Exports	5,000	40,000	+700.0
Total	178,000	280,000	+ 57.3

[1] Includes bensol—74,000 barrels in January 1940.
[2] Includes changes in terminal stocks and transfers of crude oil for fuel-oil consumption east of California (all classified as gas oil and distillate fuels) carried back to Jan. 1939.
[3] Beginning January 1940, includes both unmanufactured and manufactured asphalt—only unmanufactured previously shown.
[4] Not Available.

Toughest JOB IN TEXAS!



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pected to produce fairly well in conformity with prevailing demand.

Gasoline Situation

Having mounted above 100,000,000 barrels for the first time in history, gasoline stocks are regarded by economists as being at least 15,000,000 barrels larger than would be necessary upon entering the spring-summer season. For the actually needed stocks as of March 31 have been estimated generally from 82,000,000 to 85,000,000 barrels.

Although domestic demand for gasoline has been remarkably large, exports have been disappointing since last summer. Shipments abroad were above 1938 levels in September, 1939, but subsequently they have been under the year-ago levels. In January, 1940, latest month for which figures are available, gasoline exports totaled only 2,274,000 barrels, or 37.5 per cent less than the 3,638,000 barrels shipped out in January, 1939. And for the five months, September, 1939-January, 1940, there was a 25 per cent decrease, shipments having totaled 15,645,000 barrels, compared with 20,813,000 barrels in the corresponding months a year earlier.

Although it was generally believed at the outbreak of the European war that the hostilities would lead to large exports of aviation gasoline from the United States, that expectation has not been fulfilled. Even that product is being exported in relatively small quantities. Shipments of 155,000 barrels in January, 1940, were 72 per cent less than those of 553,000 barrels in January, 1939.

While exports of all grades of gasoline were off 37.5 per cent in January, as compared with a year previously, the total demand showed a 3 per cent increase, as domestic consumption was up 6.9 per cent. Figures on the export and domestic demands for gasoline in January, 1939 and 1940, appear in an accompanying table.

Exceptionally cold weather caused demand for heating oils to soar to unprecedented levels in the first quarter of this year. The consumption in January was described by the Bureau of Mines as sensational.

The total demand for gas oil and distillate fuel was 30 per cent greater in January, 1940, than in January, 1939, despite slightly smaller exports, as domestic consumption was up 34 per cent.

The stocks of those light oils currently are about 3,000,000 barrels, or 12 per cent, smaller than a year ago.

Demand for kerosene was 18 per cent greater in January, 1940, than in January, 1939, although exports were only one-fourth as large, the domestic consumption having shown a 31 per cent gain.

Stocks of kerosene, having been reduced in meeting the large demand, are 27 per cent smaller than a year ago.

Changes from Year Ago in Stocks of Crude and Refined Oils in the United States

(Barrels of 42 U. S. Gallons)

LATEST WEEKLY DATA

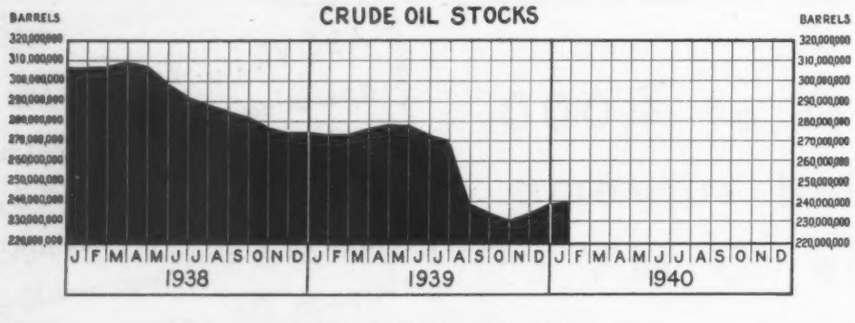
(Sources: Crude stocks, Bureau of Mines; all other figures American Petroleum Institute.)

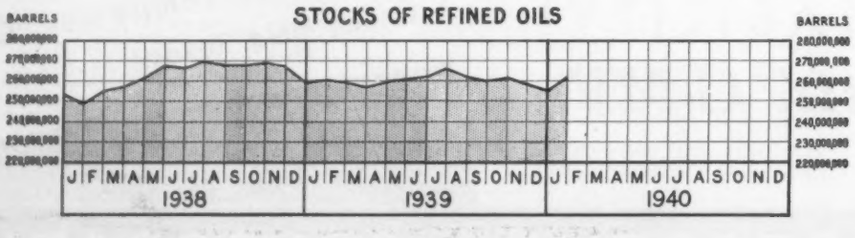
STOCKS OF:	April 1, 1939	Mar. 30, 1940	Percent Change
Gasoline	87,068,000	101,370,000	+16.3
[1]Gas Oil & Distillate Fuels	25,990,000	23,278,000	—10.4
[1]Residual Fuel Oil	109,028,000	103,081,000	— 5.5
Crude Oil	276,119,000	250,561,000	— 9.3

LATEST MONTHLY DATA

ITEM	Stocks at End of January		
	1939	1940	Percent Change
SUMMARY—			
Crude Petroleum:			
Refinable in U.S.	272,346,000	239,794,000	—11.9
Heavy in Calif.	16,356,000	13,356,000	—18.3
Natural Gasoline	4,647,000	4,476,000	— 3.7
Refined Products	272,707,000	262,791,000	— 3.6
Total, all oils	566,056,000	520,446,000	— 8.1
Days' supply:			
January basis	157	127	—19.1
PRODUCTS—			
Gasoline:			
Finished	73,847,000	84,863,000	+14.9
Unfinished	5,619,000	6,112,000	+ 8.8
Total	79,466,000	90,975,000	+14.5
Kerosene	6,711,000	4,918,000	—26.7
[2]Gas Oil & Distillate Fuels	24,650,000	21,057,000	—14.6
[2]Residual Fuel Oils	95,548,000	84,759,000	—11.3
Lubricants	7,762,000	7,328,000	— 5.6
Wax (thousands of pounds)	128,627,000	74,575,000	—42.0
Coke (short tons)	717,000,000	628,000,000	—12.41
Asphalt (short tons)	532,000,000	593,000,000	+11.5
Road Oil	830,000	763,000	— 8.1
Miscellaneous	250,000	288,000	+15.2
Other Unfinished Oils	5,619,000	6,112,000	+ 8.8

[1] At refineries only, except in California.
[2] At refineries only.





Industrial Fuel Oils

The total demand for residual fuel oil, used principally as fuel by factories, mills, ships and railroads, was 12 per cent larger in January, 1940, than in the initial month of 1939, despite somewhat smaller exports, consumption in the United States having been 13 per cent greater.

The inventories of those heavy fuel oils are about 6 per cent smaller than a year ago.

Lubricants and Wax

Lubricants, wax, and coke have shown increases in export as well as domestic demand; and asphalt shipments abroad have been relatively large, although domestic consumption of that product has lagged, along with the domestic use of road oil. Miscellaneous products not mentioned above have shown increases for both the export and domestic components of demand.

Total demand for lubricants was 27 per cent larger in January, 1940, than in January, 1939, with domestic requirements up 28 per cent and exports 25 per cent greater. Stocks of lubricants at the end of January were about 6 per cent smaller than a year previously.

The tables that are published herewith embody details for January on domestic and export demands and inventories of wax, coke, asphalt, road oil, and miscellaneous products.

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Cooperative Study Group Idea Applied To Refinery Engineering and Processing

NEAL B. LAUBACH

AN evening with the young engineers and chemists of Cities Service Oil Company's Ponca City refinery would be a tonic to those who feel that initiative, energy, and originality are words without meaning in the modern American industrial system. This group of 25 men have learned that education can be fun and technical at the same time. They acclaim their cooperative study group as the "best engineering course ever."

Organized in September, 1938, as "Advanced Refinery Engineering," this class maintained an average attendance record of over 90 percent for the first period of 28 weeks at meetings scheduled for Monday night at 7:00 p.m. and seldom ending before 10:00 p.m. Membership was open to all interested persons engaged in refinery engineering or chemistry. As finally established, the class consisted of college-trained engineers, chemists, one geologist, and a few non-college men who possessed an unusual grasp of technical subjects. Most of the men were in the refinery supervisory group except for a sizeable representation from the laboratory.

A definite need for this type of education was first recognized at the Ponca City refinery when a certain unity of interest in night-school classes for study of refinery problems and theory was observed among most of the technical men. Modern developments in refinery methods and processes seemed to be giving rise to an appetite for study on the part of the men vitally concerned with them. Strength of this feeling was tested with an organization meeting, and following a promising response, a committee was appointed to secure a copy of "Refinery Engineering," by W. L. Nelson, for each member. The writer agreed to act as group leader (similar to a college classroom instructor) to assign lessons, lead the discussions, and develop interest. Beyond this, all similarity to college work ended. It was understood that the leader was also a student and made no pretense to omniscience. Anyone could quit without notice or reason, and as soon as the group became too small, it was agreed that the class would be discontinued. The men were made to feel the burden of success rested with each one of them and it was thoroughly understood that results would be in proportion to the effort expended.

A Search for Reasons

None of the men had taken a course which they were allowed to design according to their own needs and they were quick to take the opportunity to find explanations "off the record" for processes they considered in poor accord with sound scientific knowledge. Even the leader, without realizing it at first, found himself studying long hours attempting to determine reasons for refinery practices he had thought he understood.

At present the group is functioning on this basis: no refinery subject is sacred; the questions are honest; the discussions are scientific and thoughtful—if somewhat heated at times. Tradition is recognized as the experience factor, but not a conclusive argument. Such is the group spirit.

Virtually all of the textbook was covered during the 1938 season. Classes usually were divided into two parts—theory and problems. Problems assigned usually required four to eight hours outside or home work. Because of intense interest displayed, it was possible to assign work which had a direct bearing on the local refinery situation. Exchangers, furnaces, and towers to suit specific refinery conditions were designed by the class. Operating equipment was recalculated according to formula and checked with actual operation. This type of study was not only intensely interesting, but offered a type of work without comparison or equal in classroom style of training.

A unanimous decision to start again in the fall went with the classes' election to quit in May, 1939. When the summer heat subsided and attention was given to reorganization, it was felt that a more permanent and stable organization would be beneficial. Experimental work was ended and plans could be made with greater assurance of success than in the previous year. The group was canvassed for an expression of subjects to be studied and the course decided upon was "Advanced Study of Refinery Processing and Equipment." Emphasis was still to remain on engineering. Some changes which did not affect the essential coloring were made and the class contained about the same number as the previous year. The regular set of officers consists of instructor, chairman, and secretary-treasurer, and this group acts as an executive committee to determine policy, course of study, and any other matters requiring their attention.

Search For Authority

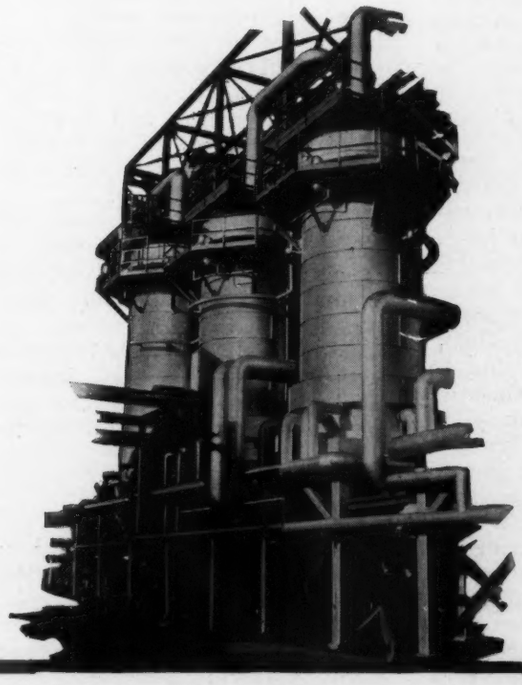
No satisfactory text was available for the subject, but previous experience enabled the group to operate without a text. Various engineering and equipment companies were petitioned for help and their response was instantaneous. Trade journals are also effective in this connection. Lack of an organized outline such as a textbook is, of course, a handicap to standardized instruction, but in this instance it served as a stimulant. Since no one authority was available for reference, it became an absorbing search for information and authority for different opinions. The greatest spur to personal industry is in the search for good authority to support a shaky opinion.

In attacking their problem the

. . . and in the Future

NOW . . . 145,000 Barrels per day of Houdry Catalytic Cracking capacity are in operation with 33,500 Barrels under construction. In addition, 40,000 Barrels of catalytic treating capacity are operating. All catalytic cracking units are producing 78-80 CFR motor method gasoline regardless of the type of charge stock.

FUTURE . . . From 12 operating Houdry units experience has been gained which is leading to improved plants. A research staff is working hand in hand with the engineers. Catalysts are constantly being improved with consequent higher yields. A Houdry license places in the hands of the refiner a proved means for the production of high octane fuels—motor or aviation.



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*Study class at Cities Service Oil Company's Ponca City refinery in night session.**

Ponca City men take the position that a refinery, when broken down to individual items of equipment, is essentially very simple. By taking each item of equipment and trying to understand its use, they find it is easy to combine various pieces of equipment into a process, and from these processes into a complete refinery.

Groups Are Effective

Variation in set-up of the group is also made. Members are divided into five groups of approximately five members. Each group has a leader who designates a meeting time and place to study a lesson for the next week. By this procedure it is possible to investigate more types of equipment and to report more fully to the class on various features. Each group, in effect, becomes expert in certain types of equipment, and it is possible in future discussions to draw on these groups much in the same manner as a large engineering organization draws on the specialized knowledge of its staff members.

During the 1939-40 season the class elected to associate itself with the Oklahoma State Division of Vocational Trades and Industries which is the agency for administration of the Smith-Hughes Act of 1917. Much credit for this connection should go to C. A. Pickel, local director at Ponca City, and to L. K. Covelle, state supervisor at the A. & M. College, at Stillwater, Oklahoma.

Having recently completed 14 weeks of intensive study, it is planned by the class to continue until a total of 24 weeks have been finished. Next year will no doubt see a continuation and improvement of the idea of cooperative study among this group of engineers and technical men.

L. N. Haugen, superintendent, and D. V. Eels, assistant superintendent; Fred Brunkau, safety and personnel director; and many others in the Cities Service Oil Company have given the organization their wholehearted support and have aided the instructor (the author) in bringing about its success.

*Instructor—Neal B. LauBach, (standing). (Viewing Class from front.)
Front row—left to right: Milton, Burkett, Ross, Keel, Owen.
Second row—Sonders, Farris, Sterba, Bowles, Hackler, Cook, Eells.
Third row—Brunkau, Whitmore, Suit, Humphrey, Christain, Rivers. Woodside.
Back row—Davidson, Miller, Connors, Parks.

Gasoline Surplus

THE LAMP, house organ of Standard Oil Company of New Jersey, has pointed to high gasoline stocks as a serious problem. "So large a volume (in storage) naturally exerts a depressing influence not only on the gasoline market but on crude prices as well," the magazine stated, "since it is axiomatic that no refiner can afford for long to pay more for his raw material than he can realize from the sale of the many products made from it."

Taking a long-range view, The Lamp commented further on gasoline stocks and their relation to sharply increasing consumption of heating oils. "There is every prospect," stated the house organ, "that with the steady growth of domestic and commercial oil burner installations, demand for distillate fuel and gas oils will continue to rise. In looking to the future, therefore, the industry's problem lies in meeting increasing and sometimes unexpected demands for distillate fuel and gas oils without unnecessarily adding to gasoline stocks in winter."

Rich in Roads

FOR building and maintaining roads and highways since 1913, motorists in the United States have spent, through gasoline and other automotive taxes, over $15,000,000,000, according to the American Petroleum Industries Committee. That sum is 2½ times the current value of the 30,000,000 motor vehicles operating on the nation's highways and is equivalent to the world's gold reserves at the old price of $20.67 an ounce. . . . However, the road and highway system could be rebuilt three times for the equivalent of the present national debt.

Now rich in roads, the country has over 385,000 miles of surfaced roads in the state highway systems and many additional miles of good roads in the secondary and county systems.

The $15,000,000,000 plus raised for roads has consisted of $8,000,000 in state gasoline taxes, $1,250,000,000 federal gasoline taxes, $5,800,000,000 state registration and other fees, and $750,000,000 federal taxes on lubricating oil, motor vehicles, and accessories.

Rainbow of Oil

THE limits of United States oil reserves begin to appear like the rainbow's end. The country consumed 1¼ billion barrels of petroleum in 1939, but at the end of the year there was a billion barrels more oil in sight than at the beginning, discoveries of the year having been nearly twice the quantity taken from the ground.

The American Petroleum Institute's committee on petroleum reserves last week reported that there was a net increase of 1,134,866,000 barrels in known underground stocks of petroleum in 1939, after deduction of the 1,264,256,000 barrels produced. The proved reserve inventory stood on January 1, 1940, at a new peak of 18,483,012,000 barrels.

Recycling Process Patents Pooled

FORMATION of the Distillate Engineering & Processes Company was announced in March. The company has acquired licensing rights in the distillate-recovery field from Eureka Process Corporation, Seaboard Oil Company, Standard Oil Company (New Jersey), Stanolind Oil & Gas Company and Tide Water Associated Oil Company. The new company will have headquarters in the National Bank of Tulsa building, Tulsa. Hugh Ownby is president, Emby Kaye vice president and general manager and Dr. Paul F. Hawley, secretary.

Basic patents covering inventions by Jay P. Walker, E. V. Foran, George S. Bays and William H. Vaughn are included. Although patents are comparatively recent, conflicting and overlapping situations were such that formation of a licensing company was adopted as a means of bringing this technological development to the petroleum industry.

The patents deal with the extraction of petroleum fractions from natural gas at high pressure and the return of dry gas to the producing formation. The methods are commonly known as distillate recovery and recycling.

Plants now operating under processes acquired by the new company are Anco Gas Corporation. Long Lake; Tide Water Associated Oil Company and Seaboard Oil Company, Cayuga and Long Lake; Process Oil Company, Agua Dulce; Portex Oil Company, Logansport.

Licensing Agreement

PHILLIPS Petroleum Company, Bartlesville, Oklahoma, and Universal Oil Products Company, Chicago, have consummated a licensing agreement on patents pertaining to the manufacture of motor fuel from oil or gas. The transaction permits Universal Oil Products Company to license the thermal and catalytic patents of Phillips Petroleum Company, which in turn has the privilege of using in its own operations all of the patents of Universal Oil Products Company, including the catalytic processes.

Not included in the agreement are the sweetening and desulfurizing processes of Phillips Petroleum Company, which are licensed by its subsidiary, Perco, Inc.

One of the processes is the development of Phillips Petroleum Company for manufacture of neohexane, which makes it possible to produce gasoline of 115 octane and higher. This process was described at the last annual meeting of the American Petroleum Institute by G. G. Overfell, vice president of Phillips Petroleum Company.

On future development of the two companies the announcement was:

"An important phase of the agreement is the cooperation of the two companies in continuing extensive research and development which will result in greater conservation of petroleum resources and bring about increased yields of higher-quality motor fuel at lower manufacturing costs. Ultimately all of these improvements will likewise be available to the industry."

The Look Box

Price Control Held Illegal

EXTENSION of license contracts, based on patents, into the field of price control was held illegal by the United States Supreme Court in ruling in the case of the federal government against Ethyl Gasoline Corporation March 25. The corporation licenses use of Ethyl fluid to 123 refiners, who in turn sell to jobbers and a part of the contract is that Ethyl gasoline of certain specifications must be sold at a certain price above other grades of gasoline.

The unanimous decision, written by Justice Stone on this point was:

"By the leverage of its licensing contracts resting on the fulcrum of its patents, it has built up a combination capable of use and actually used as a means of controlling jobbers' prices and suppressing competition among them."

He added, "this attempted regulation of prices and market practices of jobbers, which could not be brought about by contract, could not lawfully be done by manipulation."

The decision was on appeal from the federal district court of Southern New York.

CONVENTIONS

APR.	
18–19	**National Petroleum Association, Semi-Annual Meeting, Cleveland Hotel, Cleveland.**
26–27	**Petroleum and Natural Gas Conference, Pennsylvania State College, State College, Pa.**
MAY	
1– 3	**Petroleum Industry Electrical Association, Dallas.**
6–10	**American Gas Association, Natural Gas Section, Houston.**
13–15	**American Institute of Chemical Engineers, Semi-Annual Meeting, Statler Hotel, Buffalo.**
15–17	**Natural Gasoline Association of America, Hotel Tulsa, Tulsa.**
18–25	**International Petroleum Exposition, Tulsa.**
27–31	**American Petroleum Institute, Mid-Year Meeting, Blackstone and Texas Hotels, Fort Worth.**
JUNE	
9–14	**Society of Automotive Engineers, Summer Meeting, the Greenbriar, White Sulphur Springs, W. Va.**
17–20	**American Society of Mechanical Engineers, Milwaukee.**
24–28	**American Society for Testing Materials, Chalfonte-Haddon Hall, Atlantic City.**

Bureau Raises Crude Demand Forecast 1 Percent

WARNING the industry that a high level of winter runs to stills, a record accumulation of gasoline stocks and a substantial reduction in exports reduce the usual sharp spring rise in demand, the United States Bureau of Mines March 20 forecast that demand for domestic crude in April would average 3,550,000 barrels a day.

April demand was set at 49,400 barrels, or 1 percent more than the estimated demand for March and 2 percent above the actual demand in April, 1939. The bureau pointed out that this is the first increase in demand forecast since last November.

The bureau found that daily average crude production during the four weeks February 10 to March 9 was 3,769,000 barrels and runs to stills 3,489,000 barrels, while during the period domestic crude stocks increased 6,489,000 barrels, giving an indicated daily average demand for domestic crude of 3,538,000 barrels, or about 15,000 barrels above the forecast.

"Increases in the amount of Illinois crude marketed, combined with weakness in the export market for crude petroleum and motor fuel, have curtailed the markets for crude from the Mid-Continent and Gulf States," the bureau commented in summarizing the general situation. "The April forecast of demand for Illinois crude is 215,000 barrels daily above the actual of a year ago, compared with a gain in the estimated demand for the United States as a whole of only about 64,000 barrels daily. The current rate of production in other states, if continued, will result in large additions to crude stocks or will stimulate refinery operations to a degree beyond the capacity of the market to absorb refined products.

"The trends in motor-fuel demand for the second quarter indicate a possible domestic demand of 6 percent above the corresponding period of last year, but smaller exports may reduce the gain in total demand to about 5 percent. By March 31, the increased motor-fuel demand for the first quarter will not only have been met, but finished and unfinished stocks will probably approximate 100,000,000 barrels, or 13,000,000 above the level of March 31, 1939. If this seasonal surplus is eliminated during the summer months it will provide two-thirds of the anticipated increase in total motor-fuel demand in the second and third quarters.

"The demand for distillate fuel oil, exaggerated by abnormally cold weather, reached record levels in the first quarter, but should drop to a more normal level in the second quarter," the bureau added. "In the areas east of California, fuel-oil demands in April must be met from current runs to stills because of depleted stocks. To attain a normal balance between supplies of motor fuel and other products, lower runs to stills than the current level with moderate gasoline yields and higher yields of other products seem to be essential.

"The high level of winter runs to stills, the record accumulation of gasoline stocks, and a substantial reduction in exports preclude the usual sharp rise in the demand for domestic crude in the second quarter. Unless conditions change materially, no substantial

increases over the figures forecast for April, either in runs to stills or in the demand for domestic crude, seem probable for either May or June."

The bureau estimated domestic demand for motor fuel in April at 47,500,000 barrels, an increase of 8 percent over the abnormally low demand of 43,977,000 barrels in the same month last year. The estimate of exports, however, is but 2,800,000 barrels, or 863,000 barrels under shipments a year ago.

Stocks of finished and unfinished gasoline on January 31 amounted to 90,975,000 barrels, and the American Petroleum Institute estimates indicate an increase of about 9,200,000 barrels in February, bringing them to more than 100,000,000 barrels at the end of that month. The bureau estimates a decrease of 1,700,000 barrels in finished stocks during April.

With benzol and direct sales of natural gasoline estimated at 900,000 barrels, the bureau finds refinery production will be 47,700,000 barrels during the coming month, which it distributed among the various districts as follows:

East Coast, 6,360,000 barrels; Appalachian, 1,990,000 barrels; Indiana-Illinois, 9,320,000 barrels; Oklahoma, 2,760,000 barrels; Kansas, 2,490,000 barrels; Inland Texas, 3,490,000 barrels; Texas Gulf Coast, 11,820,000 barrels; Louisiana Gulf Coast, 1,470,000 barrels; Inland Louisiana-Arkansas, 850,000 barrels; Rocky Mountain, 1,250,000 barrels, and California, 5,900,000 barrels.

Natural gasoline to be blended at the refineries is estimated at 5.9 percent of total production, or 2,810,000 barrels, while the yield of straight-run and cracked gasoline is estimated at 44.05 percent. Application of this yield to production of 44,890,000 barrels of gasoline gives crude runs of 101,900,000 barrels, or 3,396,700 barrels daily. Foreign crude runs are estimated at 2,600,000 barrels.

Crude oil exports are placed at 4,900,000 barrels, 1,322,000 barrels under actual exports in April, 1939, while crude oil to be used as fuel and losses are estimated at 2,300,000 barrels, giving a total demand for domestic crude in April of 106,500,000 barrels, or 3,550,000 barrels a day. The estimated demand for crude oil by states as shown in the accompanying table.

Bureau estimate of daily average crude-oil demand for April (barrels)

(As no changes in crude-oil stocks are involved in these estimates, they represent demand rather than production)

State—	Forecast April, 1940
Texas	1,332,000
California	590,000
Oklahoma	413,000
Illinois	380,000
Louisiana	257,000
Kansas	151,000
New Mexico	100,000
Wyoming	66,000
Arkansas	64,500
Michigan	63,000
Pennsylvania	51,000
Montana	16,800
Kentucky	15,800
New York	14,900
West Virginia	11,000
Ohio	8,800
Indiana	7,800
Mississippi	3,900
Colorado	3,500
Total	3,550,000

Western Petroleum Refiners Move To Standardize Octane Ratings

AN encouraging outlook for American business was outlined by W. J. Cameron of Ford Motor Company, Detroit, at the closing business session of the twenty-eighth annual meeting of the Western Petroleum Refiners Association in Wichita, Kansas, March 31, April 1 and 2. The popular radio speaker based his estimate on a change in the spirit of business. He said there was evidence that business men had come to realize that solution of their difficulties was a responsibility of business itself.

He placed blame for the plight of business on business men. He told how they sought the aid of government in solving difficulties when they should have realized that only business can cure its ills. Both the era of prosperity prior to 1929 and era of depression of 1929 were classed as periods when business men were not paying attention to their jobs.

"It is the duty of business," he explained, "to provide the tools and facilities with which men make their living. When business men turned to the golf course and the brokerage office instead of to their own work, it was evidence that they looked upon these avenues as better places for effort. It was equally as bad when business men went to Washington to find solution for difficulties which came out of what they considered an era of prosperity.

"Now there are indications that the business man knows he must work for his own solutions. He must do it at the job of business."

Laird S. Dean, Topeka banker, in a talk on "Democracy, Business and Finance," likewise charged business with a part of the responsibility for its plight. He said business, especially large corporations, had failed in their duty of keeping both employes and the public informed as to what the proper function of business is.

"Business," he explained, "has an element that is not willing to play the game as business should be conducted. It was the duty of the other element of business to get rid of this element and to educate both its employes and the public in the honest purposes of business. Instead the small but ruthless element continued to offend with the result that government has undertaken to correct a situation by punishing business as a whole."

Technical Program.

The greater part of the program of the meeting was devoted to technical questions. Tractor fuels were discussed by Professors C. W. Smith and C. L. Zink, University of Nebraska. Arch L. Foster, Lubri-Zol Corporation, Cleveland, presented a paper, "Some Important Factors in Catalytic Cracking." W. W. Sheumann, Cities Service Oil Company, as chairman of a sub-committee, gave a digest of the situation that has resulted in continued raising of octane specifications. (see Page 62). C. M. Blair, Tretolite Company, St. Louis, outlined methods of salt removal, his title being, "Removal of Inorganic Salts from Petroleum." (See Page 67). "Thermal Reforming and Catalytic Polymerization," was the subject of R. P. Mase, Mase-Turner Company, Tulsa. (Page 71).

Resolution on Octane

The paper on the octane race was followed by adoption of a resolution by which the association adopted the A. S. T. M. method of test for octane rating and discarded the L-3. It also provided for three brackets of octane numbers for gasoline sold by association members: 72-74, 63-66 and 60 and below. The object is to have these groupings become accepted specifications as to this quality in gasoline. Gasoline of higher octane rating will be offered as premium fuel.

Discussion previous to the vote brought out that buyers insist on certain methods of test for octane rating with the result that confusion exists. A significant paragraph in the resolution, offered by C. L. Mayhall, committee chairman, was:

"We believe that it must be obvious to all that octane numbers have been over-emphasized in selling efforts. It is desirable, too, to eliminate as much as possible the misuse of the octane number in selling propaganda and start thinking and talking about actual all-around performance of motor fuels."

Activities of both the Tulsa headquarters and of the Shreveport office of the Ark-La-Tex division were outlined in the speech of L. D. Simmons, president. His remarks on these activities were:

"Each member receives from the Tulsa office regular monthly reports on crude, and refined products. These reports are compiled from the Bureau of Mines, A. P. I. and other sources.

Heads W. P. R. A.

C. L. HENDERSON

THERE IT IS . . .
without a doubt

BECAUSE the liquid level in a "PYREX" Broad Red Line Gauge Glass is easy to see, from any angle and at greater distances, more frequent checking becomes a habit with boiler room attendants. Greater safety and efficiency is the obvious result.

The fused-in, permanent, broad red line produces a readily visible dividing line in the appearance of the gauge glass above and below the water level (see illustration). Either ordinary reflected light or rear illumination effectively reveals the exact liquid level.

Complete details on "PYREX" and Corning Gauge Glasses can be obtained from any of the leading steam and mill supply houses. Ask your dealer why these glasses are more efficient and more economical in the long run.

Above is shown a reproduction from an actual unretouched color photograph which illustrates the appearance of the gauge glass from directly in front.

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Also a summary report is made of individual members' reports and given to the membership on all production, demand and stocks. These reports are compiled and returned to all members and I am sure that each company has a representative who studies these statistics and finds them to be valuable information. The office transmits to the membership inquiries for lubricating oils, greases, etc., the source of this information being the U. S. Consular Service in Washington.

"The Digest of State Inspection Laws has been disseminated in a new form which enables us to keep this up to date in a neater and more uniform manner, which covers laws for inspection of refined products in states having these laws and tax laws pertaining to refined products and gives the department that handles the inspection, rules and regulations and specifications required by our respective states and includes W. P. R. A. and U. S. government specifications on gasoline, kerosene, Diesel and tractor fuel. This book has been forwarded to all members as well as some to non-members and I am sure that they have found it to be very useful.

"The office has been very active in the discouragement of grading laws and helpful with several states in getting certain parts of state specifications eliminated or modified, which enables the refiner to make products that are saleable in all states without making special blends or modifications. This is specifically illustrated in Oklahoma, where the last legislature passed a law authorizing the Corporation Commission to write rules and regulations for petroleum products and enforcement of same, which includes octane ratings and their method of tests. Therefore, it was exceedingly important that the association co-operate with the commission in working out satisfactory rules and regulatons governing specifications of refined products. The association has been helpful in working with the commission for mutual understanding and agreement on these rules and regulations. Work of this nature will be continued in other states as vigorously as in Oklahoma.

"The manufacturing committee under chairmanship of L. D. Mann has charge of all tecnical and manufacturing programs. This chairman has spent considerable time in association work and deserves recognition for the results accomplished. During the year meetings were held in Wichita, Shreveport and at the annual meeting. The subjects were timely and about problems with which the industry is currently working.

"The octane committee has been very active in the past year under the chairmanship of C. L. Mayhall, with H. W. Camp as co-chairman. It has made field surveys in fourteen states and studied the progress of octane ratings and from time to time has made suggestions. The octane race that is under way at the present time resembles a stampede of a herd of steers. If startled, and one of them starts to run, the others will join in the race without any provocation other than that the animal by its side is moving. They do not know where they are going or why, but they are in a hell of a hurry to get there.

"This reminds me of what is taking place now. When a certain company announced a gasoline with an increased octane rating each one has proceeded to try to out-do the others in advertising to the public that you can now have 'greatly improved gasoline' 'at no extra cost.' Let's be reasonable about this and give the public in value all that they are paying for, but not try to act as a benevolent Santa Claus.

"The cracking plant inspection committee held no meetings during the past year, as they have felt that it was not necessary. They are studying the new processes, and believe that the present code adopted by the association will take care of the inspection for some time.

"The tractor fuel committee held no formal meetings but has corresponded with each other. They did not believe that it was necessary to make any recommendations at this time for the reason that the specifications of the association are ample to meet the requirements. This committee, when necessary, will make recommendations as new equipment is brought on the market.

"The Diesel fuel committee held no formal meetings for the reason there were no material changes in engine designs and the specifications as adopted by the association were satisfactory to the engine makers. This committee is keeping close contact with engine designers and manufacturers and when necessary, will make recommendations for any changes in specifications.

"The membership committee, of which C. L. Henderson is chairman, has been very active and has done exceedingly well in holding the membership to the normal level.

"All of the committees of the association should be retained, and should concentrate all their efforts on the elimination of objectionable laws in regard to inspection and taxation or the modification of same, especially working toward uniform specifications of products, so that special products will not have to be made for each state. These specifications should be drawn up and adopted by the association, which should try to get the various states to adopt them. Also, they should continue research work in regard to obtaining a uniform method of determining anti-knock values. I believe that we should co-operate with other associations that are working on this problem, especially in road tests, and wherever possible to lend every effort to this particular problem. I urgently recommend that the association as soon as possible set up standard specifications for gasolines and other refined products in order that the industry and the states may adopt them.

The Shreveport Office

"The Shreveport office, under the management of L. C. Grosjean, has been very active in its territory, which includes East Texas, Arkansas, and Louisiana. During the year he held 15 meetings with an average attendance of between 50 and 60 people, and at one meeting over 100 were present. This, within itself, shows there is a great deal of interest manifested in that territory in these meetings. They alernate between Shreveport, El Dorado and Kilgore. They have an unusual procedure in their meetings wherein they have a program of 'questions and answers' that brings out a number of problems concerning the operation of the refinery and treating of oils, as well as different kinds of material used in the manufacturing of gasoline.

"They issue weekly statistical reports on operations, also monthly statistical reports and gallonage reports covering the south and southeastern states, which are considered a real service. Grosjean also follows the action of the state governmental bodies in that area such as legislative sessions, and state organizations such as A. P. I. C. and jobber associations. Bulletins are issued from time to time on matters of special interest. In fact, many problems are handled through this office.

"I want to congratulate Grosjean for the fine work that he is doing, and I fully realize that the refiners in his district are quite well pleased with the program that he has inaugurated.

The Washington Office

"The Washington office, under the direction of Fayette B. Dow, disseminates statistics of national importance. Also, any legislation that is proposed or enacted is sent to the membership immediately. Dow, from time to time, appears before various investigating committees, either opposing or approv-

Officials of the Western Petroleum Refiners' Association

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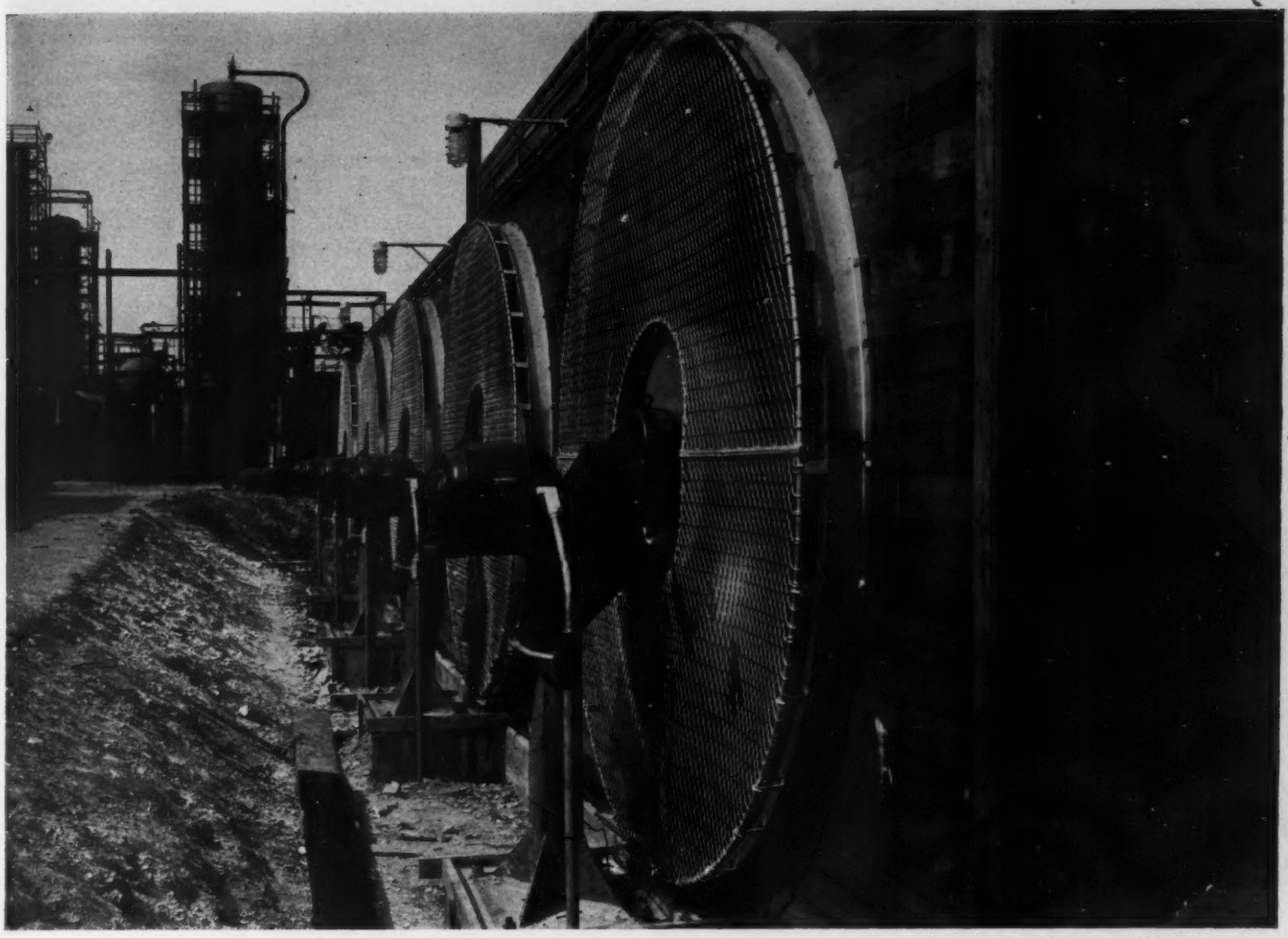
A. M. Hughes, Phillips Petroleum Company, Bartlesville.
R. R. Irwin, Socony-Vacuum Oil Company, (White Eagle Division) Kansas City.
R. E. Luton, The Ohio Oil Company, Robinson, Illinois.
F. L. Martin, Sunray Oil Company, Tulsa.
W. E. Moody, Deep Rock Oil Corporation, Cushing, Oklahoma.
I. A. O'Shaughnessy, Globe Oil & Refining Company, Minneapolis.
L. H. Prichard, Anderson-Prichard Oil Corporation, Oklahoma City.
W. F. Sims, Panhandle Refining Company, Wichita Falls, Texas.
W. G. Skelly, Skelly Oil Company, Tulsa.
J. W. Warner, Tide Water Oil Company, Tulsa.
C. B. Watson, The Pure Oil Company, Chicago.
J. A. Welch, Arkansas Fuel Oil Company, Shreveport.
H. E. Zoller, Derby Oil, Derby Oil Company, Wichita.

EX-OFFICIO DIRECTORS

C. M. Boggs, Kanotex Refining Company, Arkansas City, Kansas.
Roy B. Jones, Panhandle Refining Company, Wichita Falls.
L. B. Simmons, Rock Island Refining Company, Duncan, Oklahoma.



Prior to purchase of this 5 cell, 6700 GPM low head cooling tower, refinery engineers visited installations to check the advantages offered by Foster Wheeler developments in mechanical draft water cooling. Orders for six towers followed this investigation.

Mechanical Draft Maintains Production

Performance guarantees for refining equipment assume definite temperatures for cooling water; variations in temperatures necessitate adjustments in quantity and quality of products—prime evidence that controlled cooling of water is essential to high productive capacity.

Mechanical draft cooling towers provide process water cooled to the lowest economic temperatures. Low head construction reduces pumping charges to offset, largely, the cost of fan power.

As an example of the economics involved, if adequate cooling prevents a 2.5% carryover on a 2200 bbl. per day charge of kerosene, 55 barrels are added to marketable production and costly recovery at the separators is avoided.

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NEW YORK, N. Y.

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ing contemplated legislation. For instance, he made very vigorous opposition to the Venezuela Trade Pact and the Cole Bill. He has been very helpful to members in problems of pipe-line and other transportation tariffs. Also, he has been able to obtain quick information pertaining to patents and other matters along these lines, and bulletins promptly issued on all legislation pertaining to the oil industry. His office is very helpful because he is able to obtain this information immediately, and we feel that he saves our membership considerable time and expense.

"All Association statistics are distributed to members, to government agencies, to the trade press and to any other persons upon request."

The Finance Committee, under the chairmanship of H. T. Ashton, recommended a reduction of 40 percent in the membership dues, and I am very much gratified to state to you that we have been able to carry on the activities of the association and not impair our financial standing. The association is in excellent condition and the management has been exceedingly careful in eliminating small items of expense where possible to do so, such as telegraph, telephone, stationery, office rent, etc. We consider these matters very important in the successful operation of any business.

Petroleum Sales Company Officials Reelected

A. V. BOURQUE was re-elected president of Petroleum Sales Company, Tulsa, at the annual meeting in March. Rex H. Winget, Cushing Refining & Gasoline Company, Cushing, was reelected vice president and T. A. Helling, El Dorado Refining Company, El Dorado, Kansas, was retained as secretary-treasurer.

The directorate was reduced from 7 to 5 members: Carl L. Mayhall, Anderson-Prichard Oil Corporation, Oklahoma City; M. J. Grogan, Hurricane Oil Sales Company, Shreveport, and the officials.

Grand Old Men for Manufacturing

GOLD medals, each designated "Grand Old Man," will be awarded by the International Petroleum Exposition, Tulsa, May 18 to 25, to men in both the refining and natural gasoline divisions of the petroleum industry. Inclusion of these designations will be the first time the exposition management has set the division of manufacturing apart on this score.

John C. Day, secretary of the Western Petroleum Refiners Association, Tulsa, will seek nominations for the refining division. Those for the natural gasoline manufacturing industry will be collected by William F. Lowe, secretary of the Natural Gasoline Association of America. Nominations blanks can be had from them or from the office of the exposition in Tulsa.

"This is the first time either of these divisions has had the opportunity to honor one of its members at the exposition," said Emby Kaye, chairman of the refiners committee. "Previously the award has been for the industry as a whole."

N.P.A. Semi-Annual Program at Cleveland

THE program for the thirty-seventh semi-annual meeting of the National Petroleum Association to be held at the Cleveland Hotel, Cleveland, Ohio, April 18 and 19, has been arranged as follows:

Wednesday, April 17

6 p.m.—Executive committee, department fire and accident prevention.

8 p.m.—Western Pennsylvania Refiners Traffic Association.

Thursday, April 18

9:30 a.m.—Board of trustees.

10 a.m.—Department of manufacture: Synopsium on lubricants (speakers to be announced); automotive lubricants; Diesel lubricants; aeronautic lubricants.

Department of traffic and transportation (subject to be announced).

6:30 p.m.—Fellowship supper, Cleveland Hotel Ballroom. Entertainment hosts: Canfield - National - Sohio. Entertainment committee: Canfield Oil Company, H. M. Carruth and A. L. Bailey; National Refining Company, C. S. Smith and H. W. Kuegler; Standard Oil Company of Ohio, A. M. Maxwell and M. R. Bower.

Thursday, April 18

2 p.m.—N. H. Weber, president, National Petroleum Association, address of welcome.

"The Interests of the Public, the Motor Manufacturers and the Oil Industry in Lubrication," R. A. Ludlow, director, A.P.I. lubrication committee.

"Americanism," Carl E. Bailey, governor of Arkansas.

"Lubricating Oil Market," J. M. Koch, director, sales and advertising, Quaker State Oil Refining Corporation.

Friday, April 19

9:30 a.m.—Breakfast. C. L. Suhr, executive vice president National Petroleum Association, presiding.

"Can Germany Win?" a brief survey of the war, by Hanson W. Baldwin, military critic, New York Times. Discussion led by Prof. Henry M. Busch, Western Reserve University.

"The Octane Problem From the Automotive Viewpoint," J. B. McCauley, Chrysler Corporation. Discussion led by J. B. Fisher, Kendall Refining Company; E. B. McConnell, Standard Oil Company of Ohio; W. S. Zehrung, Pennzoil Company.

Two Programs For A.S.M.E.

SIMULTANEOUS programs of the petroleum section of the petroleum section of the American Society of Mechanical Engineers will be held at the University of Oklahoma, Norman, April 11, 12 and 13. The second annual petroleum fluid metering conference will start April 11. The next day will bring the annual meeting of the petroleum section. The two programs will be identical for most of April 12 and the annual meeting of the petroleum section will continue through April 13.

The program of the first day of the metering conference will be:

"Viscosity and its Effect on the Accuracy of Positive Displacement Metering," J. W. Donnell, University of Oklahoma.

"Fundamental Principles of Volume Meters," E. E. Ambrosius, University of Oklahoma.

"Some Fundamental Considerations in the Design and Application of Displacement Meters," E. W. Jacobson, Gulf Research and Development Company, Pittsburgh.

"Crude Production Measurements," E. O. Bennett, Continental Oil Company, Ponca City.

"Calibration of Meters in Pipe-Line Service," Henry Pohl and E. H. Counts, Sinclair Refining Company, Independence.

"The Use of Meters in Gasoline Pipe-Line Service," round table discussion led by S. S. Smith, Shell Oil Company, St. Louis.

"Report on Fluid Metering Research at the University of Oklahoma," E. E. Ambrosius, University of Oklahoma, and H. S. Bean, United States Bureau of Standards.

"The Elimination of Air from Petroleum Pipe Lines," round table discussion, led by H. G. Smith.

The metering conference will have one paper the morning of April 12, "Problems Encountered in Distillate Measurement," Earl Kightlinger, Arkansas-Louisiana Gas Company, after which the conference and the annual meeting of the section will hear the address of welcome by William Bennett Bizzell, president of Oklahoma University, and an address by Howard Coonley, chairman of the board of Walworth Company.

The technical program for the two meetings will be identical for these three papers:

"Distribution of Heat Energy, Its Measurement and Control," E. G. Bailey, Babcock & Wilcox Company.

"Displacement Meters in the Refinery," W. H. McCoy, Gulf Refining Company.

"Measurement of Individual Well Production," W. L. Kitsman, Phillips Petroleum Company.

One more paper, "Progress in the Use of Meters in Crude Pipe Line Service," by T. R. Aude, Stanolind Pipe Line Company, will complete the program of the metering conference.

There will be two papers on the program of the meeting of the petroleum section the afternoon of April 12:

"The Application and Use of Reda and Kobe Pumps in the Oklahoma City Field," N. B. Chenault, Jr., British American Oil Producing Company; and "Maintenance of Gravity for Oil in Lease Storage," Max R. Wise, Bethlehem-International Supply Company.

The technical program for the last day of the meeting of the petroleum section will be:

"The Analytical Determination of Stresses in Cylindrical Pressure Vessels Due to Saddle Supports," M. D. Green, Black, Sivalls & Bryson.

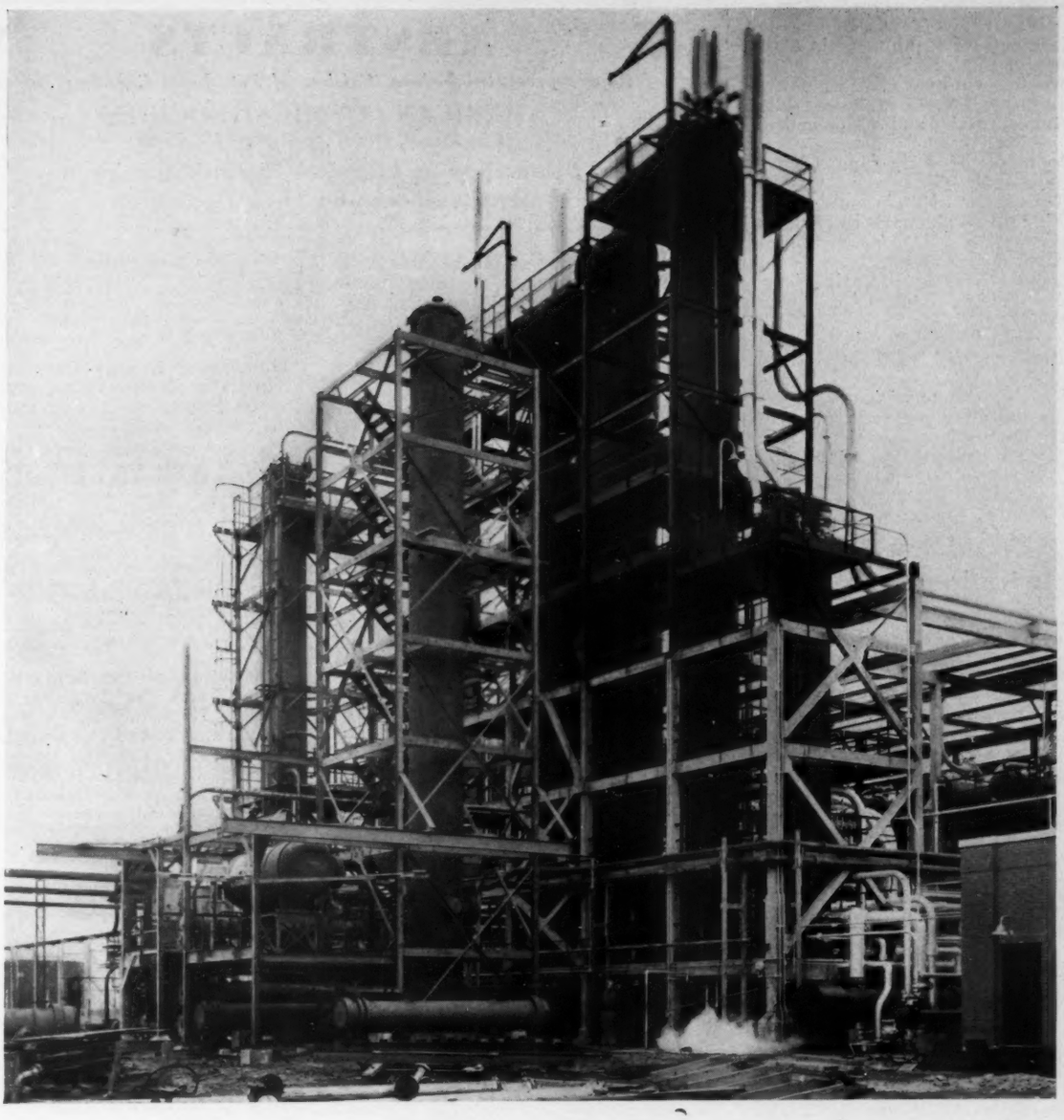
"The Economical Selection of Compressor Equipment for Gas-Lift Operation," E. O. Bennett, Continental Oil Company.

"Operating Experience with the 850 psi-900° F. Extension at Market Street Generating Station," K. P. Kammer, New Orleans Public Service, Inc.

"Construction of the Utah Pipe Line," W. G. Heltzel, Stanolind Pipe Line Company.

"Visual Studies of Flow of Air-Water Mixtures in Vertical Pipe," R. L. Huntington, University of Oklahoma.

"Performance and Design of Shell-



Poly Plant Depropanizer

This depropanizer, now completed, is an extension to the world's largest Polymerization Plant previously built by Foster Wheeler. Exceptionally close fractionation is secured between butane and propane.

Installation of new processes, such as polymerization, has caused progressive refiners to recalculate their refinery butane balance. These processes have created a shrinkage in available butane and has consequently magnified the significance of contamination with propane. It now pays to conserve butane and discard propane by Foster Wheeler close fractionation.

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and-Tube Heat Exchangers," Byron Short, University of Texas.

"Requirements of Equipment in Gas-Lift Operations," S. F. Shaw.

"Compression-Ignition Oil Engines in the Oil Industry," V. L. Meleev, Oklahoma Agricultural and Mechanical College.

"Development of Pipe-Line Charts by Dimensional Analysis," L. H. Cherry, University of Oklahoma.

"Weighing of Wells and Interpretation of Cards," P. C. Jones, Phillips Petroleum Company.

"Hydraulic Drives in Indutrial Service," J. B. Jenkins, Twin Disc Clutch Company.

"Application of Fluid-Level Measurement," Charles Rodd, Gulf Oil Corporation.

"Problems Encountered in the Maintenance of the Combustion System of Air-Injection Diesel Engine," E. R. Spencer, Texas Empire Pipe Line Company.

A.P.I. Committee On Lubrication

WILLIAM H. CORREA, Socony-Vacuum Oil Company, New York, has been appointed chairman of the committee on lubrication of the American Petroleum Institute. L. C. Welch, Standard Oil Company (Indiana), Chicago, is vice chairman and Dayton P. Clark, Gulf Oil Corporation, Pittsburgh, is secretary.

The committee will work with the automotive industry in matters pertaining to lubricants and lubrication. R. A. Ludlow is director of activities of the committee.

Members of the committee are: K. Baker, J. D. Streett & Company, St. Louis; M. B. Chittick, The Pure Oil Company, Chicago; R. Cubicciotti, Union Oil Company, Los Angeles; J. C. Day, Western Petroleum Refiners Association, Tulsa; J. M. Evans, Tide Water Associated Oil Company, San Francisco; H. P. Hobart, Gulf Oil Corporation, Pittsburgh; W. L. Holmgren, W. H. Barber Company, Minneapolis; P. V. Kane, Sun Oil Company, Philadelphia; F. C. Kerns, The Texas Company, New York; J. M. Koch, Quaker State Oil Refining Corporation, Oil City; J. H. Lee, Shell Oil Company, New York; L. P. Lochridge, Sinclair Refining Company, New York; R. W. McDowell, Mid-Continent Petroleum Corporation, Tulsa; E. V. Moncrieff, Swan-Finch Oil Corporation, New York; J. E. Moorhead, Pennsylvania Grade Crude Oil Association, Oil City; W. M. Murray, Deep Rock Oil Corporation, Chicago; E. G. Richardson, Shell Oil Company, St. Louis; J. Walter Saybolt, Standard Oil Company of New Jersey, New York; Raymond Shaw, The Chek-Chart Corporation, Chicago; D. B. Spanogle, The Atlantic Refining Company, Philadelphia, and O. J. Tuttle, Cities Service Oil Company, Chicago.

Dr. C. K. Francis Dead

DR. C. K. FRANCIS, petroleum technologist and technical editor of the Oil & Gas Journal, died at his home in Tulsa, March 25. He was a director of the International Petroleum Exposition and vice chairman of its technical committee.

ABSTRACTS

of Papers presented before Division of Petroleum Chemistry of the

AMERICAN CHEMICAL SOCIETY

Cincinnati, Ohio, April 8 to 13, 1940

Symposium on Chemical Thermodynamics of Hydrocarbons and Their Derivatives

The Present Status of the Statistical Method of Calculating Thermodynamic Functions,

E. BRIGHT WILSON, JR., *Mallinckrodt Chemical Laboratory, Harvard University, Cambridge, Mass.*

The basic formulas for the approximate calculation of thermodynamic quantities from molecular constants are summarized, including an extensive table of the harmonic oscillator contributions. Theoretical developments of recent years are reviewed, especially those dealing with the problem of internal torsional motions. A discussion of the sources of the necessary molecular constants is given, and a list, with references, of the calculations which have been published is included.

Heat of Formation of Gaseous Hydrocarbons,

FREDERICK D. ROSSINI, *National Bureau of Standards.*

The existing data leading to values of the heats of formation of hydrocarbons in the gaseous state are discussed. "Best" values are given for the heats of formation of 8 paraffin hydrocarbons (through the pentanes), 16 olefin hydrocarbons (through the pentenes), and 3 acetylene hydrocarbons, all in the gaseous state. Regularities and irregularities in the heats of formation, and their changes with structure are discussed. Forthcoming data on the hexanes are mentioned.

Some Observations on the Thermodynamics of Hydrocarbons and Related Compounds,

JOHN G. ASTON, *School of Chemistry and Physics, The Pennsylvania State College, State College, Pa.*

It is shown that it is necessary to take account of potentials hindering free rotation in calculating thermodynamic functions of hydrocarbons and related compounds from the spectrascopic and molecular data. Values obtained from the third law are correct.

By using the third law results, down to 10° K., the necessary potentials can be obtained and thermodynamic functions calculated from 300° K. to 1200° K. with the aid of the spectroscopic and molecular data.

Thus $\Delta F°/T$ values are obtained for normal butane, normal pentane, and neopentane from 300° K. to 1200° K. based on thermal data down to 10° K. obtained in this laboratory. The results on the first two make it possible to get free energy values for the higher normal paraffins.

Chemical Equilibria, Free Energies, and Heat Contents for Gaseous Hydrocarbons,

KENNETH S. PITZER, *Department of Chemistry, University of California, Berkeley, Calif.*

The statistical methods for calculating thermodynamic functions of hydrocarbons are discussed. In addition to the more common methods which are suitable for the simpler molecules, a procedure is described which is especially suited to the complex hydrocarbons and our present incomplete knowledge of their molecular constants. Agreement is obtained with all experimental data for the paraffins on the basis of reasonable rotation restricting barriers. There appear to be inconsistencies in the data for propylene, which render somewhat uncertain the values for the higher olefins.

Tables are presented which give the heat and free energy functions for all the paraffins through the heptanes, together with some discussion of estimates for the higher members. A few equilibrium constants and heats of reaction are calculated as examples of the use of this data.

Some Free Energy Data for Typical Hydrocarbons Containing Six or More Carbon Atoms,

GEORGE S. PARKS, *Stanford University, Calif.*

The third law of thermodynamics has been used to determine the free energies of formation of a number of typical hydrocarbons containing six or more carbon atoms. The sequence — paraffins, cycloparaffins, olefins, monocyclic aromatics, polycyclic aromatics— represents the general order of increasing free energy values at room temperature. The quantitative effects associated with hydrocarbon type, CH_2 increments, branching, etc., are evaluated with considerably greater accuracy than in the past, due mainly to the utilization of modern, highly reliable data for the heats of combustion involved.

Separation of the Aromatic Hydrocarbons, and the Isolation of *n*-Dodecane, Naphthalene, 1-Methylnaphthalene, and 2-Methylnaphthalene, from the Kerosene Fraction of Petroleum,

BEVERIDGE J. MAIR AND ANTON J. STREIFF.

This paper is the first report on the separation of the hydrocarbons in the kerosene fraction of petroleum, which investigation is being carried on as part of the work of the American Petroleum Institute Research Project 6. That part of the petroleum distilling between 114° and 144° C. at a pressure of 56 mm. Hg (corresponding approximately to 200° and 230° C. at 760 mm. Hg) was separated into a series of substantially constant boiling fractions. From the material distilling between 127° and 133° C. (at 56 mm. Hg), *n*-dodecane was isolated by crystallization. All of the material except the isolated *n*-dodecane was then subjected to a systematic extraction with reflux in a two-solvent process in order to separate the aromatic hydrocarbons from the paraffins and naphthenes. The "clean-up" of the traces of aromatic hydrocarbons was accomplished by adsorption with silica gel. The aromatic fractions were then systematically distilled in fractionating columns of high efficiency. From the material boiling at 56 mm. Hg between 127.0 and 127.5° C., 145 and 146.5° C., and 148.5° to 149.0° C., respectively, naphthalene, 2-methylnaphthalene, and 1-methylnaphthalene were isolated by fractional crystallization.

"Best" lots of each of the four hydrocarbons were prepared, with impurities estimated to be, in terms of mole fraction: *n*-dodecane, 0.0000 ± 0.0006; naphthalene, 0.0006 ± 0.0004; 1-methylnaphthalene, 0.0025 ± 0.0011; 2-methylnaphthalene, 0.0000 ± 0.0003. Values of certain physical properties of these four hydrocarbons, all extrapolated to material of 100 percent were determined as follows:

Hydrocarbon		*n*-Dodecane	Naphthalene	1-Methylnaphthalene	2-Methylnaphthalene
Boiling point at 760 mm.,	°C.	216.26±0.03	217.96±0.03	244.78±0.10	241.14±0.05
Freezing point in air,	°C.	−9.60±0.02	80.27±0.02	−30.77±0.06	34.44±0.02
Density at t °C.,	g/ml.	0.74512±0.00005	0.9752±0.0002	1.0163±0.0001	0.99045±0.00005
Refractive index at t °C.,	n_D	1.41951±0.00010	1.5898±0.0002	1.61494±0.00010	1.60192±0.00010
Refractive dispersion at t °C.,	n_F-n_C	0.00733±0.00010	0.0289±0.0002	0.02995±0.00010	0.02899±0.00010
Temperature of density, refractive index, and dispersion measurements,	°C.	25	85	25	40

Isolation of 3-Methylhexane, Trans-1, 2-Dimethylcyclopentane, and Trans-1,3-Dimethylcyclopentane from Petroleum,

AUGUSTUS R. GLASGOW, JR.

The presence of "isoheptane" and "dimethylcyclopentane" in the fraction of petroleum normally boiling between 87° and 98° C. has been reported by many investigators, but except for the work done by Bruun and Hicks-

How long is long life?

11-year-old Aluminum Paint on surge tank and penstocks, Cheoah Reservoir, North Carolina, still bright and good.

In the case of the surge tank and penstocks above the shoreline of Cheoah Reservoir, North Carolina, the original Aluminum Paint has seen 11 summers come and go. But it is still bright, still giving good protection against rust and corrosion.

That's not exceptional service for GOOD Aluminum Paint properly applied. Oil field jobs furnish many such examples of long life.

That four-letter word is the secret. GOOD! Applied to Aluminum Paint it means, first, a vehicle of the right viscosity and enough solids to give a paint with real body to it; a vehicle containing sufficient oil to stay elastic, not get brittle. Second, it means the proper proportion of pure, bright, high-leafing Aluminum pigment to hide well and to resist moisture, sunlight, and fumes; two pounds of Alcoa Albron Paste per gallon.

That's what makes GOOD Aluminum Paint, the kind which gives you not only longer life but also easy brushing, good appearance, high reflectivity, better hiding, and strong resistance to sulfur-containing fumes.

GOOD Aluminum Paint today is better than any the oil industry used when it first adopted Aluminum Paint many years ago. It is still the best and most economical paint for tanks and refinery equipment.

But when you buy, remember that four-letter word . . . GOOD.

WANT YOUR PAINT PROBLEMS ANALYZED? If your Aluminum Paint is not giving the life you have a right to expect, write PAINT SERVICE BUREAU, Aluminum Company of America, 1950 Gulf Bldg., Pittsburgh, Pa., makers of Alcoa Albron Paste and Powder used in GOOD Aluminum Paint.

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ALBRON *Paste for* ALUMINUM PAINT

Bruun as part of the American Petroleum Institute Research Project 6 at this bureau, no one has actually separated this fraction into any of its constituent hydrocarbons. Most previous workers attempted to identify the isoheptane fraction as 2-methylhexane or have reported that while the isoheptanes were present in considerable quantity their separation by physical means was difficult or impossible. The dimethylcyclopentane fraction has been identified as 1,3-dimethylcyclopentane or the identification has been left incomplete. Bruun and Hicks-Bruun isolated 1,1-dimethylcyclopentane from the distillate at 87° to 88° C., and 2-methylhexane from the distillate at 90° to 91° C. There is reported in the present paper by Augustus R. Glasgow, Jr., the isolation and identification of 3-methylhexane, *trans*-1,2-dimethylcyclopentane, and *trans*-1,3-dimethylcyclopentane from the distillate normally boiling between 90° and 92° C.

The fraction of a Mid-Continent petroleum boiling between 90° and 92° C., from which the aromatic hydrocarbons had been previously removed, was substantially resolved into its constituent hydrocarbons. Alternation of atmospheric distillation and azeotropic distillation with methyl alcohol separated the material boiling between 90° and 91.2° C. into a paraffinic concentrate containing approximately 75 percent of 2-methylhexane and a naphthenic concentrate. From this material *trans*-1,3-dimethylcyclopentane was isolated by crystallization from liquid ethane. A similar procedure separated the material boiling between 91.2° and 92° C. into a naphthenic and a paraffinic concentrate. From the naphthenic concentrate, *trans*-1,2-dimethylcyclopentane was isolated by crystallization from liquid propane plus methane. From the paraffinic concentrate, 3-methylhexane was obtained in the residue from distillations at reduced pressure (215 mm. Hg).

The boiling point, refractive index, freezing point, density, carbon-hydrogen ratio, and critical solution temperature in aniline were determined for the three hydrocarbons. Estimates were made of their concentrations relative to the *n*-heptane content in the original petroleum.

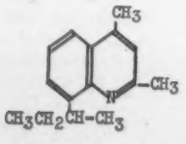
Critical Solution Temperatures and Aniline Points of Some Butane Hydrocarbons, CLIFFORD G. LUDEMAN, *The Texas Co., Port Arthur, Texas.*

Aniline points and critical solution temperatures are useful physical constants of hydrocarbons for the correlation of data. A method is outlined which enables these constants to be obtained for volatile hydrocarbons. The aniline points of *n*-butane, isobutane, and isobutene were found to be 83.1°, 107.6° and 14.9° C., respectively, and the critical solution temperatures of these hydrocarbons were 84.1°, 109.0°, and 15.8° C., respectively. These values confirm the minima which are indicated by the literature for the several hydrocarbon series of which these various butane hydrocarbons are members.

Isolation of 2,4-Dimethyl-8-sec.-Butylquinoline from California Petroleum. Degradation with Ozone to 1-Methylbutyric Acid, LESLIE M. SCHENCK AND J. R. BAILEY, *The University of Texas, Austin, Texas.*

In chromic acid oxidation of a new $C_{15}H_{19}N$ base from California petroleum; a resulting $C_{12}H_{11}NCOOH$ acid was identified as 2,4-di-methylquinoline-8-carboxylic acid [W. N. Axe, J. Am. Chem. Soc., **61**, 1018 (1939)], thus establishing one of the four butyls at position 8 on the quinoline nucleus of the original base.

In ozonization the base was degraded to 1-methylbutyric acid, $C_2H_5CH(CH_3)COOH$, a result which indicated a secondary butyl at position 8; thus was evolved for the $C_{15}H_{19}N$ base the formula,

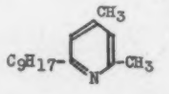


a structure now conclusively confirmed by a Combes synthesis [Cf. Bull. soc. chim., [2] **49**, 91 (1888)].

This method of identifying alkyls at position 8 in quinoline homologs is apparently of general application; at least we find that 2,3,4-trimethyl-8-*n*-propylquinoline yields *n*-butyric acid.

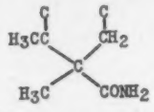
The Use of Ozonization in Structural Proof of Petroleum Bases. The Structure of a $C_{16}H_{25}N$ Base from California Petroleum, BILLIE SHIVE AND J. R. BAILEY, *The University of Texas, Austin, Texas.*

Experimental proof for the structure, of a $C_{16}H_{25}N$ base from California petroleum is submitted.



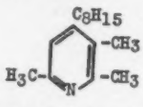
I

With ozone the base has been degraded to $C_9H_{17}CONH_2$, the $-CONH_2$ converted to -OH, and the alcohol dehydrated to two isomeric C_9H_{16} which on ozonization gave a diketone and a keto acid respectively. This establishes for $C_9H_{17}COONH_2$ the grouping.



and leaves two carbons and eight hydrogens unaccounted for. C_9H_{17} is evidently an alkylated cyclohexyl or cyclopentyl.

Structure I replaces



provisionally advanced by Roberts and Bailey [Papers presented before the General Meeting of the Petroleum Division, April, 1939, Part II, V-1. Structural Study of a $C_{16}H_{25}N$ Base from California Petroleum].

The $C_{10}H_{18}O_2$ acid corresponding to the $C_9H_{17}CONH_2$ amide has been recently isolated from a fraction of straight-run California naphthenic acids by Professor H. L. Lochte and J. T. Horeczy; thus proving a structural correlation between a naphthenic base and a naphthenic acid.

Spiral Screen Packing for Highly Efficient Laboratory Fractionating Columns, H. S. LECKY AND R. H. EWELL, *Department of Chemistry, Purdue University, Lafayette, Ind.*

A new type of packing embodying a continuous flat spiral of metal gauze enclosed between two concentric tubes is described. This packing gives very high efficiencies, 32 plates per foot or 0.375-inch H.E.T.P., exceeding the Stedman conical wire gauze packing. It is also characterized by large throughput without loss of efficiency, small holdup and small pressure drop. The performance is compared with a number of common types of packing, including the Stedman packing.

The Calculation of the Effect of Reflux Ratio in Batch Fractionation, ARTHUR ROSE AND H. H. LONG, *The School of Chemistry and Physics, The Pennsylvania State College.*

Distillation curves have been calculated for representative cases of batch fractionation under various reflux ratios. Curves are given to show the relation between (1) reflux ratio and size of intermediate fraction, (2) effect of increase in number of plates on size of intermediate fraction for a typical distillation at finite reflux, (3) reflux ratio and purity of certain fractions of distillate, (4) curves calculated by use of theoretical plate concept and by transfer unit concept. The limitations of the calculations, and the several methods of calculation are discussed.

Improved Calculation Methods of Absorber Performance and Design, GEORGE HORTON AND W. B. FRANKLIN, *Technical Service Division, Humble Oil & Refining Company, Baytown, Texas.*

This paper presents the derivation of general absorption and stripping factor equations. No assumptions are involved, and hence the equations are applicable to all cases of absorption and stripping. A simple rule is presented to estimate the knockout or stripping gradient from plate-to-plate, and two methods of calculating absorber performance are illustrated.

These methods of calculating absorber and stripper performance have been compared to plate-to-plate calculations. In spite of discrepancies on intermediate plates, good overall agreement was obtained between both methods and the plate-to-plate calculations.

Catalytic Dehydrogenation of Representative Hydrocarbons, ALEX G. OBLAD, ROBERT F. MARSCHNER, AND LLEWELYN HEARD, *Standard Oil Company (Indiana), Whiting, Indiana.*

Representative hydrocarbons of all classes have been dehydrogenated over chromic oxide catalysts using identical reaction conditions. Cyclohexanes are converted to aromatics and hydrogen for extended periods without extensive formation of gaseous and residual by-products. Paraffins are much less rapidly converted and the activity of the catalysts declines rapidly through deposition of elementary carbon. Olefins are more readily converted than paraffins, but the activity decline and carbon deposition are far more pronounced. Cyclopentanes are slowly dehydrogenated but closely resemble olefins in carbon deposition. Simple methylated aromatic hydrocarbons are unaffected but alkyl aromatics with longer side-chains, such as ethylbenzene, slowly dehydrogenate, giving tar-like by-products which strongly poison the catalysts.

H. B. Barnard Enters Consulting Practice

H. B. BARNARD, who has been associated with subsidiaries of Consolidated Oil Corporation since 1917, has resigned and will engage in practice as a consulting engineer. After the World War he was assistant general superintendent of Sinclair Pipe Line Company. From 1920 to 1930 he was vice president of Sinclair Oil & Gas Company, in charge of the gasoline department with supervision over construction and engineering of natural gasoline plants. For the last four years he has been in the executive department of Sinclair Prairie Oil & Gas Company in a consulting and advisory capacity on production and other problems.

Appalachian Meter School

THE third Appalachian Gas Measurement Short Course will be held August 19, 20 and 21 at the University of West Virginia, Morgantown. The general committee has designated the following chairmen for subcommittees: program, B. P. Stockwell, West Virginia Public Service Commission; registration, W. A. Staab, West Virginia University; entertainment, A. D. MacLean, Pittsburgh Equitable Meter Company; exhibits, J. W. Allison, Monongahela West Penn Public Service Company; publicity, B. S. Reed, Jr., Pittsburgh Equitable Meter Company; rules, H. O. Borden, American Meter Company; practical methods report on "Testing Positive Displacement Meters in the Field," J. E. Overbeck, Columbian Engineering Corporation, on "Testing Orifice Meters, A. K. Kraus, Peoples Natural Gas Company; educational, H. J. Wagner, Public Service Company of West Virginia.

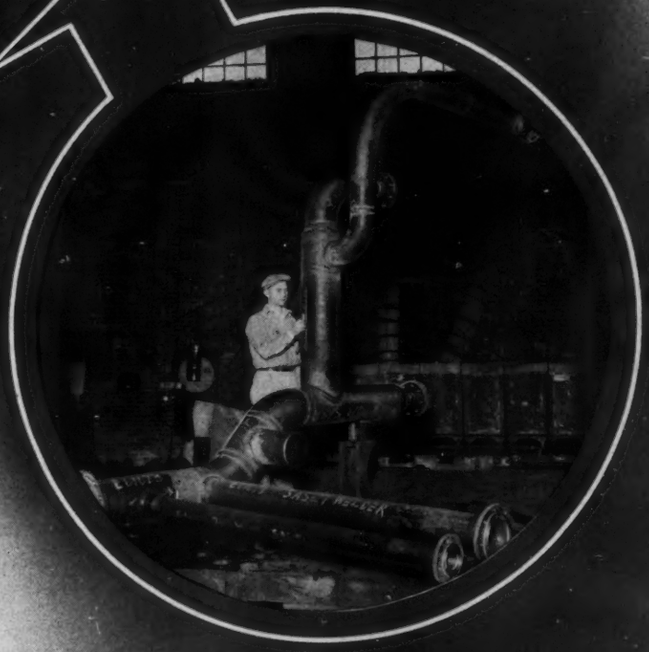
Indiana Legal Staff Changes

BUELL F. JONES has been named general counsel of Standard Oil Company (Indiana) following retirement of L. L. Stephens, who will continue in an advisory capacity until December 31, 1940.

Stephens joined the legal department in 1924. Jones has been a member of the staff since 1930 and was senior general attorney previous to his promotion.

PIPING BY
MIDWEST

Precision Pre-Fabrication SAVES YOU MONEY



Everybody knows that precision pays . . . that parts which fit immediately save so much money in assembly that any other kind are prohibitive in cost.

Precision in piping also pays. Piping by Midwest is pre-fabricated into a series of sub-assemblies which fit together precisely . . . which make erection a matter of relatively few field joints. Savings of time and money are obvious. In addition, the resulting piping job is superior.

Midwest Piping is pre-fabricated in modern plants, by skilled piping specialists, under controlled manufacturing conditions. Proper machinery is available to assure quality work; welders and other workmen are well trained. The work is directed by men of long experience in every type of piping.

Call on Midwest for Piping—no matter how small or how large the job.

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Los Angeles—520 Anderson St. • San Francisco—426 Call Bldg. • New York—(Eastern Division) 30 Church St. • Tulsa—533 Mayo Bldg.

Build Plant to Make Rubber at Baton Rouge

STANDARD Oil Development Company has made an agreement with Standard Oil Company of Louisiana for the erection of a Buna synthetic rubber plant at Baton Rouge, Louisiana. The plant will have a capacity of approximately 10,000 pounds per day and is expected to begin operations the latter part of this year.

Firestone Tire & Rubber Company has taken a license from Standard Oil Development Company to manufacture its own requirements of Buna rubber and it is understood will be prepared to produce on a small scale in the immediate future.

One of the other leading rubber companies has already informed Standard Oil Development Company that it will draw its supplies of Buna from the Baton Rouge plant, and this plant will also furnish, on an economical basis, the requirements of the large number of manufacturers of rubber specialties who have been using the imported Buna, supplies of which have been cut off since the war began.

Construction work will be done by the Baton Rouge refinery gang now on payroll. It will be located within refinery limits. When in operation, the plant will require about 25 men to run it.

Operations will consist of taking butadiene, mixing it with acrylo-nitrile, and polymerizing to obtain Buna rubber.

Welding Is a Simple Operation

A RECENT statement by J. F. Lincoln, president of the Lincoln Electric Company, classes arc welding as a simple operation, about which too much mystery has been gathered. He said:

"Arc welding has too many doctors. An operation which is perfectly natural, very simple and very easily accomplished, has largely been changed in the minds of the public to an art which takes on the mystery of voodooism with an admixture of the art of the medicine man.

"The public is beginning to think that the welding operator is a cross between a miracle man and a professional musician. This opinion is groundless. The only thing that a welding operator can do is to hold the end of an electrode at a certain distance above the deposited metal and advance it along the seam to be welded at a certain speed. There is nothing more that is involved in this operation. It is neither complicated nor difficult. As a matter of fact, with proper electrode, proper setting of the welding machine and proper preparation of the work, it is practically impossible to make a weld which will not stand up in service without having it so evident to the inspector that he would immediately reject it. It is possible to have defects in the steel that cannot be seen which will make a steel structure dangerous. It is impossible, however, to make a weld on that structure which is dangerous without it being obvious to anyone looking at the weld.

"The reason we hear so much about the necessity of skill and care in welding is largely due to the fact that the operation itself is so simple that it is difficult to find much about it to discuss in papers, lectures and statements. Therefore, many of these eccentricities which are volubly discussed in magazine articles, lectures and statements, consist of theoretical possibilities which exist only in the minds of the lecturers and seldom exist in reality.

"It is time that we got away from trying to make this very simple operation mysterious. It is time that we recognize the fact that the metal deposited by the shielded arc electrode is definitely better than the parent metal it is joining. It is time we recognized that there has never been a failure on an insured pressure vessel made by the shielded arc process. It is time we recognize that in the usual design if only half a weld is made it will withstand all of the normal requirements of the structure. It is time we recognize that failures in welds which are made by the methods recommended by any reliable manufacturer never exist. It is time we recognize that there is no mystery in welding and that making a welded joint is far more simple than making a riveted joint and more simple than making the steel which is joined together by this process. It is time we recognize that to spend time, money and attention in removing the least possible flaw from the deposited metal is silly in the light of the obvious flaws which must occur in the parent metal. A factor of safety is used to guard against these flaws. That is more than is needed in any commercial weld.

"When we do recognize these facts we will have done two things: First, we will have given the green light to one of the most economical processes now known for the production of many structures; secondly, we will have removed one of the fears which the uninitiated have developed regarding a perfectly normal manufacturing operation."

Looking at Tanker Rates

INVESTIGATION of the causes for increases in tanker rates from the Gulf Coast to the Atlantic seaboard is under consideration by the Temporary National Economic Committee, although it is not likely that this will be undertaken soon. Protests against the rate increases led to a recent conference between representatives of the United States Maritime Commission and officials of larger oil companies.

Following this conference E. S. Land, commission chairman, said this body had no authority over rates, since tankers are owned by oil companies or are under charter to them. Concerning the rate increase he said:

"Charter rates in our protected domestic trade are controlled apparently by independent tanker owners. In the Venezuelan trade charter rates are controlled by foreign owners. However, there is no evidence that either independent American owners or foreign owners were withholding tankers from the market to force charter prices upward."

He expressed the opinion that better weather and improvement in convoying would result in more tanker space for coastwise movement."

New Public Relations Group

A SUBCOMMITTEE on external relations has been named by W. S. S. Rodgers, chairman of the central committee on public relations of the American Petroleum Institute. The chairman of the subcommittee is J. W. S. Bessonnette, The Pure Oil Company, Chicago.

Those asked to serve on the subcommittee are: Russell B. Brown, Independent Petroleum Association of America, Washington; Francis H. Case, Wadhams Oil Company, Milwaukee; Frank H. Dewey, Oil Burner Institute, New York; Fayette B. Dow, National Petroleum Association, Washington; A. C. Godward, W. H. Barber Company, Minneapolis; Walter J. Held, Standard Oil Company of California, San Francisco; M. E. Holland, National Association of Petroleum Retailers, Racine, Wisconsin; Frank Spencer, Spencer Petroleum Company, Chicago; Paul Truesdell, Universal Oil Products Company, Chicago; J. F. Winchester, Standard Oil Company of New Jersey, New York, and C. J. Yokum, Petroleum Transit Corporation, Detroit.

Conger Reynolds, Standard Oil Company (Indiana), Chicago, a member of the administrative committee on public relations, will serve as an advisory member of the subcommittee.

Bill Would Stop Transporting Oil in Boats

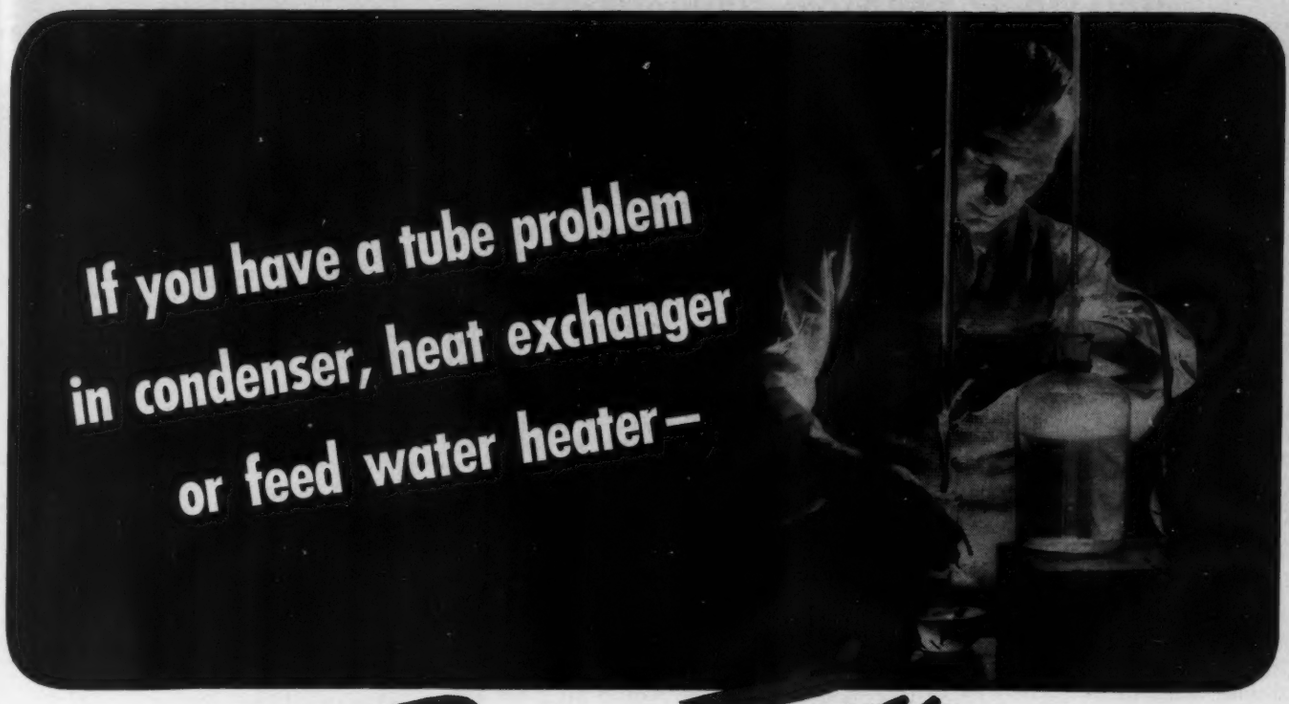
DIVORCE of water transportation from other branches of the oil industry is sought in a bill introduced in the Senate April 4 by Senator Guy M. Gillette of Iowa, who last session sponsored a bill to divorce pipe-line transportation.

The measure would make it unlawful on or after January 1, 1941, for any producer, refiner or marketer of petroleum products to operate tankers or barges, and violations would be subjected to the penalties of fines running to $10,000 for each offense committed.

The purpose of the bill is to make effective a policy of Congress enunciated in its opening paragraph of protecting consumers of petroleum products from exorbitant charges for fuel oil and petroleum supplies "brought about by the arbitrary power exercised by producers and refiners of petroleum products who have heretofore occupied the dual position of producers and transporters."

Although Senator Gillette aimed his bill at water transportation and titled it the "Oil Tanker and Barge Divorcement Act," its provisions, as written, it was held in some quarters, would divorce all forms of transportation since it would make it unlawful "for any person directly or indirectly to be engaged in the transportation of petroleum products while such person or affiliate of such person is also engaged in one or more of the other three branches of the petroleum industry, namely, production, refining and marketing."

The bill also calls upon the attorney general to examine the relationships of persons now engaged in one or more branches of the industry and to institute suits for mandatory injunctions commanding any person to comply with the provisions of this act.



A Suggestion

Nominal Compositions of Anaconda Condenser Tubes

Alloy	*Copper%*	*Nickel%*	*Zinc%*	*Aluminum%*	*Tin%*	*Arsenic%*
Super-Nickel 701	70	30	—	—	—	—
Cupro Nickel 712	80	20	—	—	—	—
Ambrac* 850	75	20	5	—	—	—
Ambraloy 901	95	—	—	5	—	—
Ambraloy 927 (Patented)	76	—	21.95	2	—	0.05
Admiralty Alloy 442	70	—	29	—	1	—
Arsenical Admiralty 439	70	—	28.95	—	1	0.05
Red Brass 85%	85	—	15	—	—	—
Tobin Bronze* 452	60	—	39.25	—	0.75	—
Muntz Metal 65	61.5	—	38.5	—	—	—
Copper, Arsenical Deoxidized 108	99.68	—	(Phosphorus, 0.02%)	—		0.30

*Trade-marks Reg. U. S. Pat. Off.

Anaconda Tube Sheets

We produce a complete line of plates and circles for marine and stationary condensers, heat exchangers, feed water heaters and oil coolers. The same careful technical supervision used to control the manufacture of Anaconda Condenser Tubes is given this material during the entire process of production.

THE service life of condenser tubes is determined in the main by the inter-relationship of such operating factors as condenser design, temperatures, character and velocity of the cooling water and the presence of air or solid matter in the water. Actual service conditions thus set up are so many and varied that no one tube alloy can solve all problems.

To determine the tube alloy that will give the greatest service per dollar of cost in your plant, we suggest that you consult with our engineers. Having a rich background of metallurgical experience and a practical knowledge of operating practices, they are particularly well equipped to cooperate with you in the selection of condenser tube alloys to meet any given set of conditions. Naturally, their services are at your disposal without cost or obligation.

2438

ANACONDA
from mine to consumer

Anaconda Copper & Brass

THE AMERICAN BRASS COMPANY, General Offices: Waterbury, Connecticut

In Canada: Anaconda American Brass Ltd., New Toronto, Ont. • Subsidiary of Anaconda Copper Mining Company

▼ PLANT ACTIVITIES ▼

New company: Double Eagle Refining Corporation has been chartered as an Oklahoma corporation by W. E. Rees, Robert R. Rittenhouse and J. T. Ryan. The firm, with capital of $25,000, has its headquarters in Oklahoma City.

Desulfurization Unit: A Perco catalytic desulfurization unit is being installed at the Brickland, New Mexico, refinery of McNutt Oil & Refining Company.

Propose Plant at Brownsville: W. R. Davis & Company have started construction of a 245,000-barrel tank farm on a 200-acre site on the ship channel at Brownsville, Texas, in the first step of a program said to include erection of a refinery. Docking facilities are being constructed at the port, and arrangements have been made to run crude from the Rincon field of Starr County.

New California Plant: Mid-Coast Oil Company plans construction of a 2500- to 3000-barrel refinery at Santa Monica, California.

Dewaxing at Houston: Sinclair Refining Company has started construction of a $1,500,000 dewaxing plant at its refinery at Houston, Texas.

Complete Expansion at Port Arthur: Gulf Oil Corporation has completed its $500,000 unit for producing 15,000 gallons of iso-octane gasoline daily, second such unit to be constructed at its refinery in Port Arthur, Texas. Output of the new unit will be mixed with 25,000 gallons of high-test gasoline to produce 40,000 gallons of premium aviation fuel.

Poly Plant for Inland: Inland Empire Refining Company, of which D. F. Gerstenberger is general manager, is installing a 500,000-cubic-foot U. O. P. catalytic polymerization unit at its plant in Spokane, Washington. The plant is now running about 2000 barrels of crude from Montana's Cut Bank field, cracking about 1000 barrels daily.

Expansion in Mexico: Petroleos Mexicanos plans installation of a solvents plant at its Arbol Grande refinery and further improvements to double the plant's present capacity of 7000 barrels daily.

Cracking for Rothschild: A 2200-barrel Dubbs cracking unit and a 500,000-cubic foot U. O. P. catalytic polymerization unit is being installed in the Rothschild Oil Company refinery at Santa Fe Springs, California. The refinery, a skimming plant, is now running 3000 barrels of Signal Hill and West Montebello crude.

Modernization at Petrolia: The present topping and cracking unit of Canadian Oil Companies, Ltd., at Petrolia, Ontario, Canada, is being modernized in line with Dubbs operating methods. The plant will run about 2800 barrels of Illinois crude daily, cracking about 1300 barrels of topped crude. A U. O. P. catalytic polymerization unit and equipment to reform 500 barrels of straight-run gasoline and naphtha a day is also being installed. Provision is being made for later conversion to 2-coil-operation of the cracking unit with 2000-barrel capacity.

Refinery for Tussy Field: Winkler & McQueen, Inc., of Duncan, Oklahoma, has started construction on a 700-barrel refinery in the Tussy field, Carter and Garvin counties, Oklahoma. The company which has production of over 1000 barrels daily, will be general purchasers when the plant is completed.

Sweetening at St. Elmo: The Carter Oil Company has installed a 20,000-gallon per day Perco copper sweetening unit at its recently-completed Taylor gasoline plant near St. Elmo, Illinois.

Recycling in East Texas: Recycling, an operation that made its debut in East Texas less than three years ago, is to have its most outstanding growth in 1940. The six plants now in operation, including one started in December 1939 will be augmented by at least five more units. Recycling units now in operation range from $100,000 to near $500,000 in valuation, and though operators are reticent at the present stages of their plans to give cost figures on the new projects to be installed, gas production potentialities are sufficient to justify the larger capacity plants in at least three of the new locations.

Plants now recycling gas, taking it from the Woodbine, separating out the distillate, and returning it to the same formation from which it was taken, included Tide Water Associated Oil Company's unit at Cayuga; plants of Trinity Gas Corporation, Tide Water Associated Oil Company and Anco Gas Corporation, all located in the Long Lake field; Portex Oil Company's plant in the Joaquin field, and American-Liberty Oil Company's plant in the Grapeland field.

Projected new recycling gas plants contemplate producing their distillate-laden gas from the same Woodbine formation. Present operations find their intake volume best within a narrow range around the 6000-foot level. Operating gas pressures on the recycling plants have been reported variously at from 12,500 to 25,000 pounds back pressure, depending upon the well, with the Joaquin pressure generally a bit higher than in the other producing fields.

Largest of the recycling plants now in operation in East Texas is Tide Water Associated Oil Company's plant at Long Lake, which has a capacity of 60,000,000 cubic feet of gas daily.

H. L. Hunt has filed an application for a gas recycling plant in the Long Lake field. Grapeland Oil Company has been granted a permit for constructing a recycling plant in the Grapeland field. Lone Star Gas Company has permits for a fourth gas well and has completed three gas wells at Grapeland for production to supply a recycling plant it proposes to erect right away. Roeser & Pendleton plan to erect a recycling plant in the Cayuga field, making two there. Tide Water Associated Oil Company is reported ready to start building its second plant in the Long Lake field, making a total of four plants in that field.

Comparative operation reports on the six gas recycling plants in East Texas as compiled by the Texas Railroad Commission's Kilgore office for December, 1939, and January, 1940, most recent months on which data has been compiled are as follows:

	Dec. 1939	Jan. 1940
No. gas intake wells	17	19
No. injection wells	11	11
Intake gas volume, M.C.F.	*120,319	143,056
Disposition of Gas, M.C.F.		
Extraction loss	* 3,055	3,721
Plant use	* 5,640	5,721
Drilling	* 0	348
Pipe Line	* 1,548	2,474
Repressured (into ground)	*109,790	130,520
Vented vapors (burned)	* 286	272
Production		
Daily average gallons distillate	96,000	130,658
Average gallons recovered per thousand cu. ft. gas	0.798	0.913

*Thousands.

This comparison shows that during January two additional gas intake wells were added and that the resultant dry gas was re-injected into the ground without necessity of adding more injection wells.

Also significant during January was an increase of 0.115 gallons per thousand cubic feet of gas in the distillate recovery shown on the composite report for all six plants.

Short Course In Welding

A SHORT course in welding engineering will be held April 16, 17 and 18 under direction of the welding division of the industrial engineering department of Ohio State University, Columbus. The course is the outgrowth of a four-year course in welding engineering, which was started at the university one year ago. The short course is further explained in the official announcement:

"After the inception of this course, the welding division discovered that there were many practicing engineering who needed but lacked basic training for welding engineering. The division felt a distinct obligation to provide these men with the opportunity to get basic instruction in some of the fundamentals which form the welding-engineering curriculum."

Three courses will be held daily on such subjects as welded joints, fundamental mechanics, welding symbols and production welding.

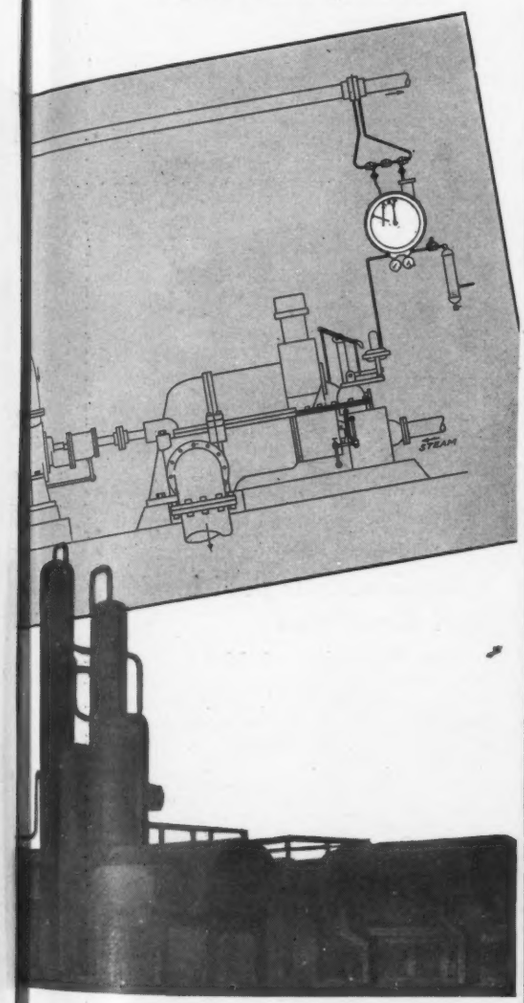
Refining and Recycling

REFINING and recycling will be discussed on the program of the Petroleum and Natural Gas Conference at Pennsylvania State College, April 26 and 27. M. B. Chittick will discuss special and by-products in refining, while F. W. Laverty will discuss the application of retrograde condensation as it applies to Eastern oil and gas production.

The conference is a cooperative effort of the college, the Pennsylvania Grade Crude Oil Association, Bradford District Pennsylvania Oil Producers Association and Pennsylvania Natural Gas Men's Association.

faster"

Flow Control on Turbine Driven Centrifugal Pump.



FOXBORO INSTRUMENT RECORD

Stabilflo Valves Have Improved Features

An improved line of "Stabilflo" controlled valves designed for accurate response to the demands of a control instrument, without sacrifice of rugged construction, are now being offered by Foxboro.

As equipped with a wide range V-port plunger, the Stabilflo valve has a rangeability of 50 to 1. When this valve is lifted off the seats, the initial clearance flow is 2%. From this 2% flow to 100% flow, the valve gives equal percentage increases in flow for equal amounts of valve lift. The V-port plunger is screwed and pinned to the valve stem and designed for easy field reversal. In addition to this V-port valve plunger, a parabolic plug type and a wide radio turned plug type are also available for exceptional control applications.

The body and plunger of the Stabilflo valve are designed for high lift. This is absolutely necessary in order to produce a valve with wide range flow characteristics that modern automatic controllers require. High lift construction also affords twice the movement for the same air pressure change as ordinary valves. The accuracy of positioning is twice as great—a vital matter on many processes.

Accurate and efficient operation of the complete line of valves is provided by the Stabilflo floating power motor. Suspended construction of this motor eliminates the need for guides and anti-friction bearings. The motor, which may be removed without in any way disturbing the motor adjustments or the relation between valve and motor, is protected from accidental injury by the low center of gravity and rugged connection to the valve. It has also been designed with sufficient excess power to enable it to meet all operating conditions.

Excess friction is also combatted in the one-piece bonnet and stuffing box assembly. The bonnet is joined to the valve body with a ground tongue and groove connection, assuring perfect alignment of the body and bonnet. Use of a deep lubricated stuffing box and polished stainless steel valve stem reduces stuffing box friction to a minimum. The stainless steel gland nut and packing follower need never be more than finger tight—eliminating trouble from rusty threads. A ring type packing is used for tighter sealing.

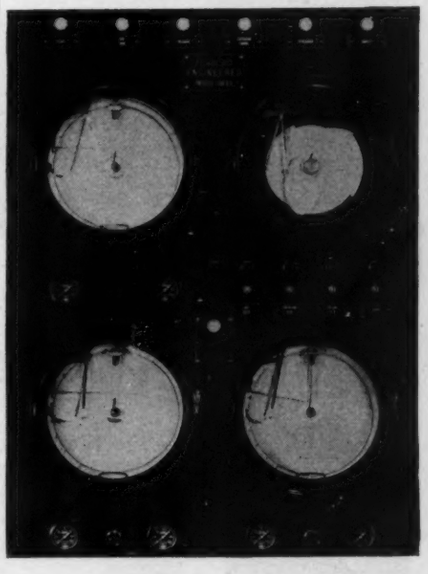
Plungers of the Stabilflo valves are provided with top and bottom guides of polished stainless steel. The guiding surfaces are large in both diameter and depth, insuring freedom from excess wear. The spider construction of the guide supports prevents the deposit of sediment that would otherwise interfere with the operation of the valve. *(Foxboro Bulletin 789)*

Time and Sequence Systems Described in Booklet

The principles, operating characteristics and application advantages of Foxboro-engineered time and sequence systems for automatic process operation are discussed in an 8-page illustrated booklet recently issued by Foxboro.

Foxboro's simple TIME CYCLE systems operate from a *single cam* to actuate successive steps of operation and control in a predetermined time cycle. The time periods of the steps may vary from seconds to hours, and during *each* of these periods any kind of process operation—the maintenance of any desired control—can be provided.

In Foxboro's simple SEQUENCE CYCLE systems, each successive step in the process automatically comes into play



when the product condition indicating completion of the *preceding* step (its temperature, pressure, volume or other factor) is reached. Hence, critical condition-factors, rather than time intervals, determine the rate at which one operation follows another. A combination of time and sequence systems for control of a single process may also be made.

In the bulletin, a typical process with instruments for completely automatic operation is shown, along with a step-by-step explanation of the function performed by the instruments from the beginning to the end of the cycle. *(Foxboro Bulletin 241)*

SCIENCE AND TECHNOLOGY

Abstracts prepared in co-operation with the

REFINER AND NATURAL GASOLINE MANUFACTURER

by

THE LESLIE LABORATORIES

Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Specific Heat of Methane under Pressure, O. N. TRAPEZNIKOVA AND G. A. MILYUTIN, *Nature* **144** (1939) p. 632.

The specific heat of methane was determined at pressures of 1-2000 kg./sq.cm. and at temperatures of 12-30°K. An anomaly was found at 20.6°K. and 1 atmosphere; it follows a straight-line relationship to 30°K. at 2000 kg./sq.cm. Another anomaly was found at 18.5°K. at 1000 kg./sq.cm., and was followed to 27°K. at 2000 kg./sq.cm. If D is substituted for H in the molecule the effect on the position of the first maximum is the same as is caused by an increase in pressure. CD_4 at 1 kg./sq.cm. is equivalent to CH_4 at 1410 kg./sq.cm.

Viscosity of Liquids at High Hydrostatic Pressures, R. B. DOW, *Phil. Mag.* **28** (1939) pp. 403-22.

High-pressure viscometry is considered with reference to both absolute and relative methods of measurement. A concentric-cylinder viscometer is described that can be used up to 3000 kg./sq.cm. The results obtained measuring the viscosity of a Pennsylvania oil agree with those found with a rolling-ball method. Bridgman's falling-ball viscometer was used to measure viscosity coefficients for 6 CS_2-CCl_4 solutions at 30° and at 75°C. and up to pressures of 10,000 kg./sq.cm. The data indicates that viscosity is not a simple function of the concentration of the components. There is no indication however, that the degree of molecular interlocking suddenly changes either with temperature or with pressure. The thermodynamic aspects of high pressure are considered and the deficiencies of known equations of state are reported. Part of the energy of viscous flow cannot be measured by thermodynamic quantities, and there is no adequate theory to cover it.

Physical Constants of Asphaltic Bitumens, Part I, R. N. J. SAAL, W. HEUKELOM, AND P. C. BLOKKER, *Jour. Inst. Pet.* **26** (1940) pp. 29-39.

The authors comment on the lack of physical data covering many of the properties of asphaltic bitumens. Such data as are available, covering penetration, softening point, brittleness, ductility, viscosity and temperature susceptibility are of greater importance for road building than in connection with other applications of asphaltic materials. The physical constants in question are in general only slightly affected by the consistency and origin of the bitumens; i.e., they are characteristic of fairly large groups of bitumens. For this reason the physical properties of only a few bitumens belonging to the different groups were determined. The properties covered were: specific gravity, coefficient of cubical expansion, specific heat, thermal conductivity, permeability to water vapor, surface tension, and total surface energy. The methods used for the determination of each of these properties are described, and data are presented in tabular form. References to previously available data are given, and comparisons with these earlier data are made.

1 SEAMLESS
2 UNIFORMLY FULL PIPE THICKNESS
3 SELECTIVE, UNIFORM REINFORCEMENT
4 TANGENTS
5 MACHINE TOOL BEVELLED
6 ENDS MARKED IN QUARTERS
7 COMPLETE IDENTIFYING MARKS ON EVERY FITTING
8 A FULL LINE
Of course
— the fittings with the MOST advantage are the fittings that can be used to BEST advantage.. WeldELLS have these eight features that are combined in no other welding fittings.
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Chemical Compositions and Reactions

The Formation of Mono- and Divinylacetylene from Acetylene in Homogeneous Catalysis, H. SCHMITZ AND H. J. SCHUMACHER, *Zeit. fur Elektrochemie & Angewandte Physikalische Chemie* **45** (1939) pp. 503-17.

The polymerization of acetylene to mono- and divinylacetylene as catalyzed by a dilute acid solution containing ammonium and cupric chloride was studied as a continuous process at absolute pressure of 1, 1.75 and 2.5 atmospheres and within the temperature range 60-110°C. The concentration of the two catalytic chlorides was varied, as well as the velocity of flow and the extent of stirring. A copper reaction vessel was used. The catalytic solutions contained from 25 to 45 percent of cupric chloride. As the velocity of flow was increased the yield increased, and the percentage of divinylacetylene in the mixture dropped to a certain point. As the degree of agitation increased the total yield increased, but the content of divinylacetylene became smaller. It was concluded that at least two acetylene complexes with different cupric chloride content existed in equilibrium solution, of which the one with the higher cupric chloride content was the more active.

Fundamentals in the Catalytic Closure of Open-Chain Hydrocarbons, H. S. TAYLOR AND J. TURKEVICH, *Trans. Faraday Soc.* **25** (1939) pp. 921-34.

The ring closure of open-chain hydrocarbons whereby aromatic compounds are formed is discussed and considered from the viewpoint of the available thermodynamic data. The catalysis of these reactions is reviewed, and it is shown experimentally that with a chro-

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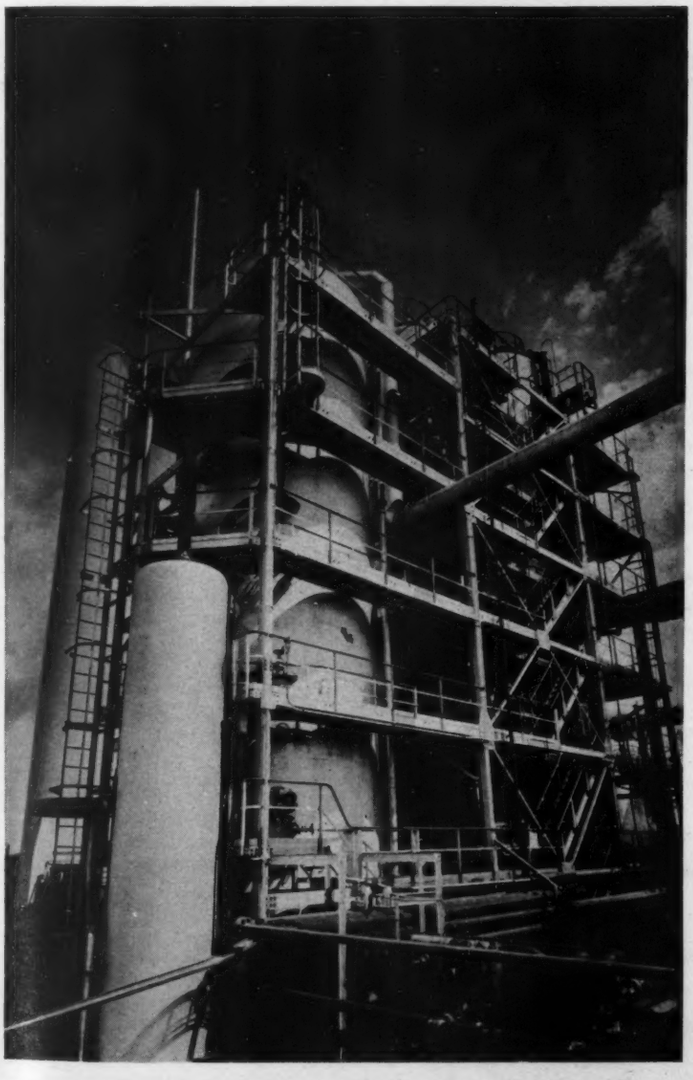

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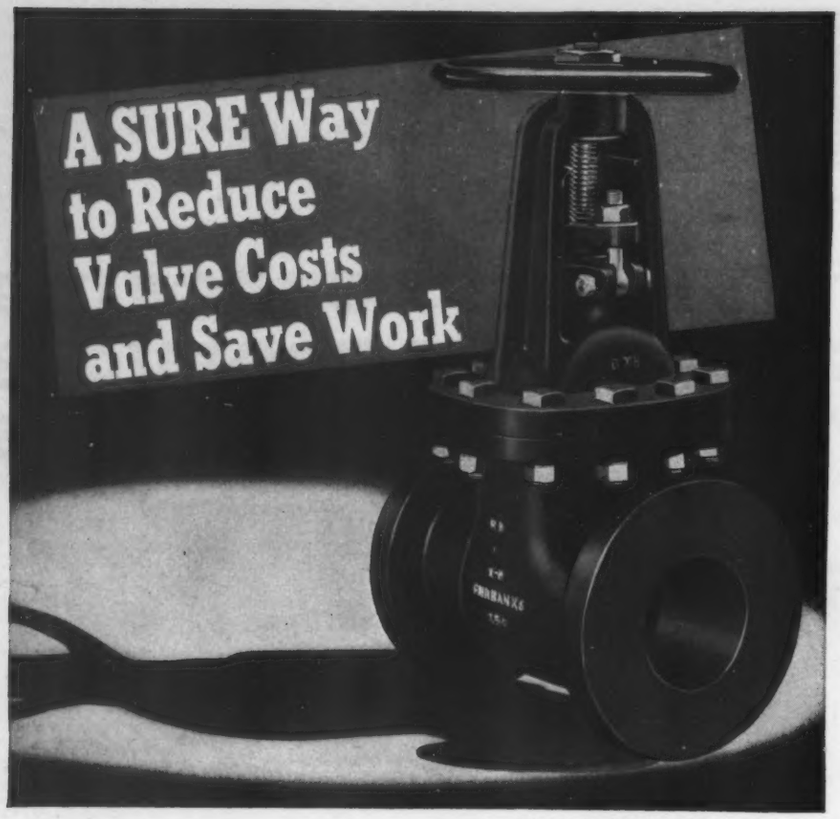

Fig. 0312, 250 lb. S.W.P.

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mium oxide gel catalyst at 476-516°C. the quantitative conversion of heptane to aromatic hydrocarbons is obtained. The effects of contact time, poisons, and temperature on the nature of gaseous and liquid products are noted for the chromium oxide gel catalyst and considered typical of a large group of oxide catalysts.

Pyrolysis of 2-Carbon and 3-Carbon Paraffin and Olefin Hydrocarbons, M. W. TRAVERS, *Trans. Faraday Soc.* **35** (1939) pp. 860-4.

I. Equilibrium Mixtures. The equilibrium reactions in ethane at 600°C. are so rapid as to maintain a condition closely approaching equilibrium in the system C_2H_6—C_2H_4—H_2. Other reactions are superimposed leading to the formation of CH_4 and condensation products.

II. Pure Ethane. (M. W. Travers and J. A. Hawkes) Ibid. 864-6. In the pyrolysis of pure ethane at 590°C. no propane is formed, and only a little propylene or butylene, not exceeding 0.4 percent. The primary decomposition process is influenced by surface to a considerable extent.

III. Influence of Nitric Oxide on the Secondary Decomposition of Ethane, Ibid. 866-8. The formation of CH_4 is not inhibited by the presence of NO, nor is the formation of aromatic condensates inhibited. This was shown by heating a mixture of C_2H_6—C_2H_4—H_2 with successive increasing quantities of NO; the NO had no influence on the secondary decomposition.

The Action of Fluorine Upon Some Simple Aliphatic Chlorinated Hydrocarbons, W. T. MILLER, *Jour. Am. Chem. Soc.* **62** (1940) pp. 341-4.

The reactions of several chlorinated aliphatic organic compounds with fluorine have been studied. Among these compounds were chloroform, pentachloroethane, tetrachloroethane, tetrachloroethylene, and trichloroethylene. Using pure fluorine, charring was not observed in any case and reactions were easily controlled. However, fluorine prepared without special precaution may contain a considerable percentage of oxygen. Such a gaseous mixture is unsuitable for reaction with organic compounds because of its oxidizing action. The types of reactions observed, using pure fluorine, were: substitution of hydrogen attached to saturated carbon; substitution of hydrogen attached to double bonded carbon; addition to ethylene bonds; dimerization of saturated molecules by removal of two hydrogens; dimerization of ethylene derivatives accompanied by the addition of two fluorine atoms; and secondary reactions caused by the presence of chlorine fluoride. The reaction conditions used and the results secured are described and discussed briefly.

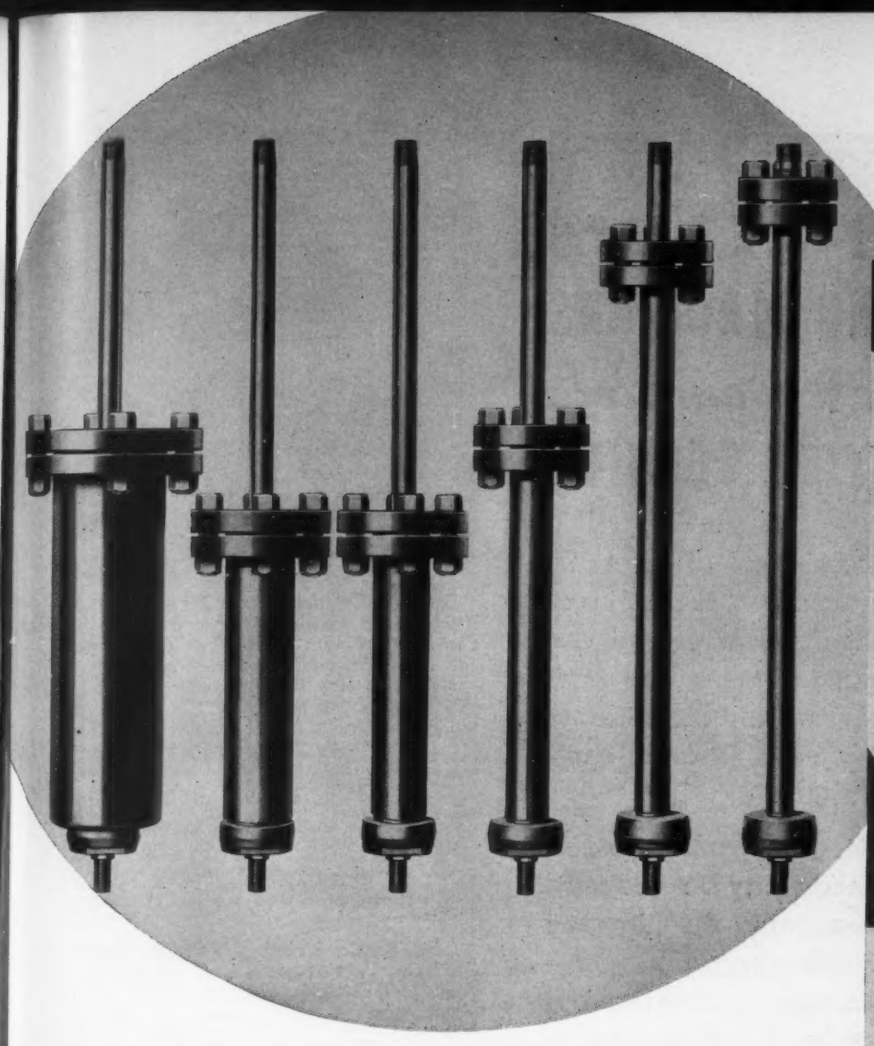
The Action of Elementary Fluorine Upon Organic Compounds. VII. The Vapor Phase Fluorination of Ethyl Chloride, J. D. CALFEE, N. FUKUHARA, D. S. YOUNG, AND L. A. BIGELOW, *Jour. Am. Chem. Soc.* **62** (1940) pp. 267-9.

The results of further work on the fluorination of hydrocarbon chlor derivatives is reported. Using the improved technique previously described ethyl chloride was fluorinated in the vapor phase over copper gauze under varying conditions, and the relative amounts of the more important products determined. The compounds CF_4, CF_3CL, CF_3CF_2Cl, $CF_2=CCl_2$ and CHF_2CH_2Cl were isolated. The three last named have never been obtained before by the action of elementary fluorine or an organic compound. An exact analytical procedure for the determination of fluorine and chlorine in stable organic gases is described.

Products: Properties and Utilization

Vapor-Lock Properties of Motor Fuels, T. HAMMERICH, *Oel u. Kohle* **15** (1939) pp. 569-77.

Vapor-lock properties of fuels are controlled, in the United States, by Reid vapor-pressure measurements and the determination of the 10% recovery point in the A.S.T.M. distillation. These methods have not been adopted generally in Germany because the results do not accord well with practice. Because the appearance of vapor-lock depends on factors other than volatility, a method was used for the determination of the lock temperature. The fuel under test was forced, at 10 liters/hour, by means of a membrane pump, through a copper spiral immersed in a water-bath. The bath was heated, and the temperature of the fuel in the spiral at the moment when a vapor-lock occurred was taken as the lock temperature. Tables and diagrams are given showing the effect of the addition of C_3 and C_4 hydrocarbons on the vapor pressure, A.S.T.M. 10%



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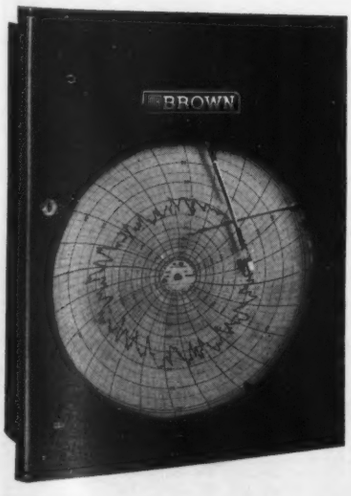

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point and lock temperature of I.G. standard benzene, and for mixtures of gasoline, alcohol, and benzene. Data show that there is an approximately linear relationship between lock temperature and A.S.T.M. 10% point for most gasolines, but that this does not hold for benzene or alcohol mixtures, or for gasolines rich in C_3 and C_4 fractions. For this reason the author proposes, as a more reliable guide to vapor-lock properties, the mean of the recovery to 50°C. and to 70°C., this to be reported as the volatility and expressed as a percentage. When volatility is plotted against lock temperature, straight lines are obtained for fuels of equal vapor pressure. If plotted on a single diagram, the lines corresponding to different vapor pressures form a pencil of rays, the slope being a function of vapor pressure. A graph of this relationship is included; thus, if the volatility (v) is known, the lock temperature (l) is obtainable from the equation $l = \frac{30 - v}{\tan a} + 48$. Hence, from measurements of Reid vapor pressure and determination of the A.S.T.M. distillation curve, it is possible to calculate the lock temperature, which is directly a measure of the vapor-lock tendencies of the fuel.

Ignition-Quality Rating of Diesel Fuels by Commercial Engines, J. S. CHANDLER, *Penna. State Coll. Eng. Expt. Sta. Serv., Bull. No.* **47** (1939) 80 pp.

Tests were made using 7 fuels of different ignition qualities in 9 commercial engines of various types and sizes. The ratings of these same fuels were determined by the Cooperative Fuel Research engine. The results indicate that the ignition-quality ratings as determined by commercial engines do not differ more on the average than 1.56 cetane numbers among themselves, but that they are on the average 3 cetane numbers higher than the C.F.R. engine rating. The engine type has a greater effect on the rating than the particular technique used. The results indicate the desirability of a slightly more representative engine for laboratory rating. However, it is felt that the correlation found was encouraging.

The Static Friction of Lubricated Surfaces, A. FOGG AND S. A. HUNWICKS, *Jour. Inst. Pet.* **26** (1940) pp. 1-18.

The object of the investigation was to obtain information on the boundary friction and the boundary lubricating properties or oiliness of various substances. The two chief properties of fluids that determine their lubricating value are viscosity and another property, independent of viscosity, usually known as oiliness. Under static conditions any effect of the property is absent. The only resistance to the commencement of motion, therefore, is that caused by the attractive forces between the solid surfaces as modified by the layer of lubricant between them. The effectiveness of this boundary layer in reducing the attractive forces is a measure of the boundary lubricating properties of the particular lubricant which must be closely associated with oiliness. By means, therefore, of measurements of the resistance to the commencement of motion, i.e., the measurement of static friction, a direct measurement of a property associated with oiliness can be made. The authors consider that in order to assess the value of a substance as a lubricant it is necessary to consider, at least, the three following factors: (1) viscosity-temperature and possibly viscosity-pressure relationships; (2) chemical stability; (3) lubricating value under boundary conditions. The apparatus, a modification of the Deeley apparatus, is described. Great attention was paid to the cleaning of the surfaces. The use of solvents was avoided, the surface being cleaned with abrasives, finally in the presence of the oil itself. Among the oils tested were: straight lubricating oils ranging from fatty oils to highly refined mineral oils, extreme pressure lubricating oils, graphited oil and compounded oil, and a number of common liquids. Oleic acid had the lowest coefficient of static friction of any of the substances tested, 0.08. The fatty oils were next, the extreme pressure oils next, and the lubricating oils next. A synthetic lubricating oil fell within the range of measurement of the common lubricating oils. The authors conclude that the machine used and the technique of operation applied gave results sufficiently consistent to distinguish easily between the oiliness of different classes of oils and of the oils in each class. It is believed that a test of this nature should be included among those for the evaluation of lubricating oils. Further work is to be done.

Laboratory Method for Evaluating the Influence of Lubricating Oils on Carbon Deposition in Internal-Combustion Engines, H. A. EVERETT AND G. H. KELLER, *Penna. State Coll. Bull., Eng. Expt. Sta. Ser., Bull No.* **48** (1939) 35 pp.

A simple and inexpensive laboratory test for predicting the carbon-forming characteristics of lubricating oils utilizes a battery

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of small, single-cylinder engines. Mechanical devices for measuring carbon formation were not successful. When oils were overheated without actual contact with flame or with the incandescent products of combustion, no appreciable carbon was deposited, but when the oil was similarly in contact with flame or products of combustion, carbon was deposited. In tests with commercial engines, after thorough cleaning, the cylinder heads were weighed to 0.001 grams. Each test included five 8-hour periods and the heads were weighed at the end of each period. The pistons were weighed only at the end of the test. After each test of any given oil a 40-hour test was made with a reference oil consisting of a blend of 180 Pennsylvania neutral and Pennsylvania overhead bright stock. The data were plotted against time, to give a curve of the average cylinder-head carbon formation for each oil. The authors consider that the accuracy of individual results is probably no greater than $\pm 10\%$.

The Iodine Number of Hydrocarbons, H. GROSSE-OETRINGHAUS, *Brennstoff-Chem.* **19** (1938) pp. 417-27.

Methods for the determination of the iodine number of hydrocarbons were critically studied, particularly as regards sources of error, limitations, and the significance of I values in connection with the study of the unsaturated compounds in cracking products. Among the methods studied were the Hanus, H. P. Kaufmann, Wijs, Margosches, McIlhiney, thiocyanate, iodothiocyanate, partial I number and the Cl-I number. Determinations were made by these methods, and the effect of the variables such as time, concentration and aging were made. Twelve gasolines and 8 oils were studied. It was concluded that the Wijs method is rarely applicable to gasoline because of substitution. Best results were obtained with the method of Hanus. Neither method, however, is suitable for lubricating oils. With lubricants results were only approximate; large differences were found. A new Cl-I method for use with hydrocarbons is described. The data are tabulated, and 34 references are given.

Determination of the Mercaptan Sulphur in the Calorimetric Bomb, E. DITTRICH, *Brennstofftechnik,* **20** (1939) pp. 348-9.

Sulphur in the form of the lower aliphatic mercaptans can only be determined in oils if the combustion in a calorimetric bomb is effected at a starting pressure of at least 500 lbs./sq. in., and if the mercaptans are present in small percentages. On the other hand, exact results can be established by combustion in the quartz tube according to the method of Grote and Krekeler.

Analysis of Naphthenic Acids, J. R. M. KLOTZ AND E. R. LITTMANN, *Ind. & Eng. Chem., Anal. Ed.* **12** (1940) pp. 76-7.

In the determination of naphthenic acids the customary procedure of extracting the unsaponifiable material with ethyl or petroleum ether from a strongly alkaline solution of sodium naphthenate possesses several disadvantages. The method is described that avoids these disadvantages. A sample of the naphthenic acid is exactly neutralized to phenolphthalein with 0.5 N sodium hydroxide, any phenols and nonacidic materials are then removed by extracting the solution with petroleum ether. The purified naphthenic acids are then recovered from the aqueous solution by acidification, and are weighed and titrated. Details of the procedure are described, and precautions given for its application. Typical data secured by the method are tabulated, and cover the acids from several different types of crude oil.

Manufacture: Processes and Plant

Catalytic Dehydrogenation of Gaseous Paraffins, A. V. GROSSE AND V. N. IPATIEFF, *Ind. & Eng. Chem.* **32** (1940) pp. 268-72.

The dehydrogenation of the paraffin hydrocarbons to the corresponding olefins is a problem of fundamental importance to the petroleum industry, because the olefins are important raw materials. A process for the conversion of paraffins into olefins makes the paraffins also important raw materials. A catalytic process of dehydrogenation is described, including a discussion of the catalysts and their preparation. Thermodynamics of the process are briefly considered, and experimental results are compared with calculated data. Typical results are given showing the extent of the conversion and its dependence on space velocity, temperature, and age of catalyst.

Preparation and Structure of High Molecular Weight Polybutenes, R. M. THOMAS, W. J. SPARKS, AND P. K. FROLICH, *Jour. Am. Chem. Soc.* **62** (1940) pp. 276-80.

The polymerization of isobutene at low tem-

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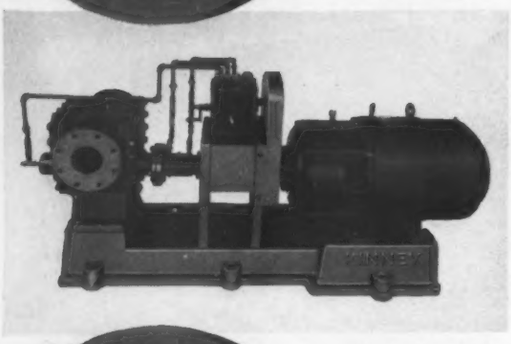

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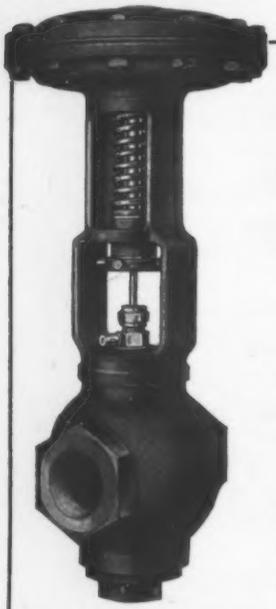

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peratures, with catalysts of acidic nature takes place with almost explosive violence, and is among the most rapidly completed of organic reactions. Under proper conditions it is possible to obtain an almost quantitative yield of rubber-like solid from liquid isobutene within a fraction of a second. This reaction is of particular interest in that it is characterized by the absence of any apparent decrease in rate of reaction with lowering of temperature, and also by the fact that polymers of the highest molecular weight are obtainable at the lowest temperatures. The paper is in the nature of an abstract of a large amount of information dealing with various aspects of the subject. The effect of the purity of raw materials, the effect of poisons, the nature of catalysts, the effect of temperature, the influence of diluents, the effect of catalyst concentration, and the structure of the polybutenes, are among the subjects considered in varying degrees of detail.

Calculation of Chemical Equilibrium at High Pressures, R. H. EWELL, *Ind. & Eng. Chem.* **32** (1940) pp. 147-53.

The utility of the third law of thermodynamics, combined with modern thermal data, for calculating the equilibrium constants of chemical reactions is demonstrated, with applications to such reactions as, the hydration of olefins, the methanol synthesis, and the reaction of nitrogen and acetylene to give hydrogen cyanide. Practical methods of calculating fugacities and activity coefficients of gases are developed, including the use of Berthelot's equation of state and a new modification of van der Waals' equation. The complete quantitative statement of LeChatelier's principle is discussed and applied to the calculation of some chemical equilibria at high pressures. The equilibrium concentrations of methanol, ethanol, and hydrogen cyanide in the above reactions are favored more than a simple calculation would indicate on account of their low activity coefficients. Raoult's law is applied to the calculation of high-pressure equilibria involving liquid phases. The equilibrium concentration of ethanol from the hydration of ethylene decreases with increasing temperature and increases rapidly with increasing pressure, so that it should be possible to condense concentrated ethanol from the reaction gases after reaching equilibrium at 150°C. and pressures as low as 100 atmospheres.

Extraction of Mercaptans with Alkaline Solutions, D. L. YABROFF, *Ind. & Eng. Chem.* **32** (1940) pp. 257-62.

The differences in the extractability of the various mercaptans from an oil phase by an aqueous alkaline solution are caused almost entirely by differences in the solubility of the unneutralized mercaptan in the aqueous phase, rather than by differences in the acidity of the various mercaptans. As the sodium hydroxide concentration in the aqueous phase increases, the improvement in the aqueous phase increases, the improvement in the extraction of mercaptans becomes less than might be expected from the higher caustic concentration. This results from the salting-out of the unneutralized mercaptan from the aqueous phase by the sodium hydroxide. The extent of the extraction of mercaptans increases as the temperature is decreased, because of decreased hydrolysis of the mercaptide in the aqueous phase. The effect of adding substances that increase the solubility of the mercaptans in the active phase is discussed. These are called solutizers. A rigorous method for calculating the extent of the extraction of mercaptans in a once-through countercurrent system is given. The entire subject of the removal of the mercaptans has recently been realized to be of greater importance than formerly thought. Through sweetening the mercaptans have been converted to dissulfides. These compounds are not, however, as innocuous as supposed; they adversely affect the lead susceptibility and also the color stability of gasolines.

The Development of the Technical Applications of Hydrogenation, E. F. ARMSTRONG AND K. A. WILLIAMS, *Chem. & Ind.* **59** (1940) pp. 3-9.

The authors review the subject of hydrogenation in all of its applications. The first part of the article considers the hydrogenation of the animal and vegetable oils. Following this, the processes for the preparation of hydrogen are briefly described, and the advantages and applications of each stated. Hydrogenation of petroleum and of coal is next considered. In addition to producing oil from coal by direct hydrogenation it is noted that the synthetic processes in which coal is first gasified and the gases catalytically treated for the production of hydrocarbon polymers may be much more important. The German and English processes are both briefly considered, and it is pointed out that the efficiencies of these procedures may be quite high.

Solvent Action of Liquid Propane, C. S. KUHN, JR., *Ind. & Eng. Chem., Anal. Ed.* **12** (1940) pp. 86-90.

A study was made of the liquid phases formed by the action of liquid propane on

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Two and a half million cars went to the motor graveyard in 1939 and more than one refiner's market went with them—refiners who make low octane gasoline

Consider the figures At an average of 725 gallons apiece (A. P. I. estimate) those cars used up a total of almost 2 billion gallons of gasoline a year—and their octane requirements were low

Who will use that low octane gasoline now?

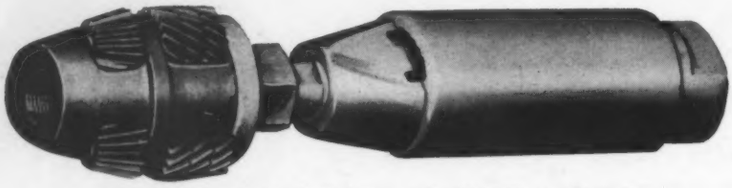
Not the 3,244,000 new cars that went into service in 1939 and not the new cars coming out this year—they are mighty particular about their motor fuel

If you are making gasoline for cars that have gone to the scrap heap, here is a suggestion:

Make Dubbscracked gasoline for today's cars

Universal Oil Products Co
Chicago, Illinois

Dubbs Cracking Process
Owner and Licensor



A WILSON "Matched Unit" . . . An E P (Extra Power) Heavy Duty Air Motor and a Wilson F P T Cutter Head

SAVE AIR, TIME AND MONEY— AND DO A BETTER CLEANING JOB

The new Wilson E P (Extra Power) Series Heavy Duty Air Motors develop 30% to 75% **more power** and use from 25% to 40% **less air** than ordinary tube cleaning motors of the same size.

Their high power enables them to clean tubes faster and cleaner—thus saving down time and assuring longer runs—and their low air consumption reduces air cost to such an extent as to make them the most economical as well as the most efficient tube cleaning equipment you can buy for the removal of excessively hard, heavy or gummy deposits from tubes or pipes.

There is a Wilson tube cleaning motor and cutter head or other accessory especially suitable for cleaning any size or kind of cleanable tube or pipe from 5/8" O.D. to 20" I.D.

Write for the name of our representative nearest to you or send for our new thirty-six page catalog fully describing and illustrating the complete line of Wilson tube cleaning equipment.

THOMAS C. WILSON, Inc.
PIPE AND TUBE CLEANERS EXCLUSIVELY
55 Vandam Street New York City

PETROLEUM DICTIONARY
By HOLLIS P. PORTER
A Registered Engineer

This work grew out of a demand for some source of definition for the terms used by the petroleum industry. It contains over 3,000 definitions of words used constantly by all phases of the petroleum industry. It was published in 1936 and has found its way into engineering departments, legal departments and land departments of producing concerns, as well as to the desks of executives of the petroleum industry.

Manufacturers also find it valuable for reference. Advertising agencies find it a valuable addition to the library.

253 PAGES, 6 x 9, CLOTH BOUND,
PRICE POSTPAID, $3.00
SEND ORDER TO

THE GULF PUBLISHING CO., P. O. Box 2811, Houston

the pentane-soluble fraction of a high-temperature bituminous coal tar. As the ratio of propane to tar was increased there was an increase in the average density, refractive index, and molecular weight, and a decrease in hydrogen-carbon ratio of the extract, and corresponding changes in the residue. The separation was largely on the basis of molecular weight, but at high tar-propane ratios there was some evidence that alkylated cyclic structured compounds were preferentially extracted. In general, there is a tendency for oxygen, nitrogen, and sulfur compounds to concentrate in the residue.

Potential Use of Hydrogen Fluoride in Organic Chemical Processes, J. H. SIMONS, *Ind. & Eng. Chem.* **32** (1940) pp. 178-83.

Hydrogen fluoride promises to be used extensively in organic chemical processes, and may become of considerable importance in connection with the utilization of refinery and other hydrocarbon gases. Fortunately, hydrogen fluoride can be made available in large quantities. Present indications are that it will displace other condensing agents and will be used to effect many new reactions not possible with other agents. Higher yields are to be expected both because obnoxious by-products such as tarry residues are not formed and because the starting materials not used can be recovered. Its physical properties are such as to result in more efficient processing, and greater ease and less cost in the design and use of equipment. Equipment can be made of common materials of engineering construction.

Fractionation of Mixtures of Hydrocarbons, H. MACURA AND H. GROSSE-OETRINGHAUS, *Oel u. Kohle* **15** (1939) pp. 591-600.

The fractionation of solutions of benzene, toluene, and xylene, using columns of different types and with various packings, is described in some detail. The effect of the different packings on the efficiency of the column is discussed, and also the effect of different rates of distillation. Using the column finally described, it is claimed that the distillation curve shows clearly the presence of toluene in a solution containing 10% benzene, 0.5 toluene, and 89.5% xylene.

Detergents from Kerosene. Alkyl Sulfates, A. R. PADGETT WITH E. F. DEGERING, *Ind. & Eng. Chem.* **32** (1940) pp. 204-8.

Hydrocarbons from kerosene boiling at 95-100°C. (15 mm.) were chlorinated to yield 80-90 per cent of the monochlorides. The chlorides were changed to alcohols with a yield of about 30 per cent, the remainder of the chlorides forming unsaturates. The alcohols were converted to the corresponding sodium alkyl sulfates. The 2-, 3-, 4-, 5-, and 6-dodecanols were prepared (the 4- and 5-dodecanols probably for the first time), and the corresponding sodium alkyl sulfates were obtained from them. Sodium lauryl sulfate was prepared from 1-dodecanol. The sodium alkyl sulfates were compared by means of a foam test and an interfacial tension test. These tests indicate that the foam value and the ability to lower the interfacial tension for a given chain decreases progressively from a maximum for the primary to a minimum for a symmetrical secondary sodium alkyl sulfate. The sodium alkyl sulfates obtained from kerosene appear somewhat inferior to similar compounds with a terminal polar group.

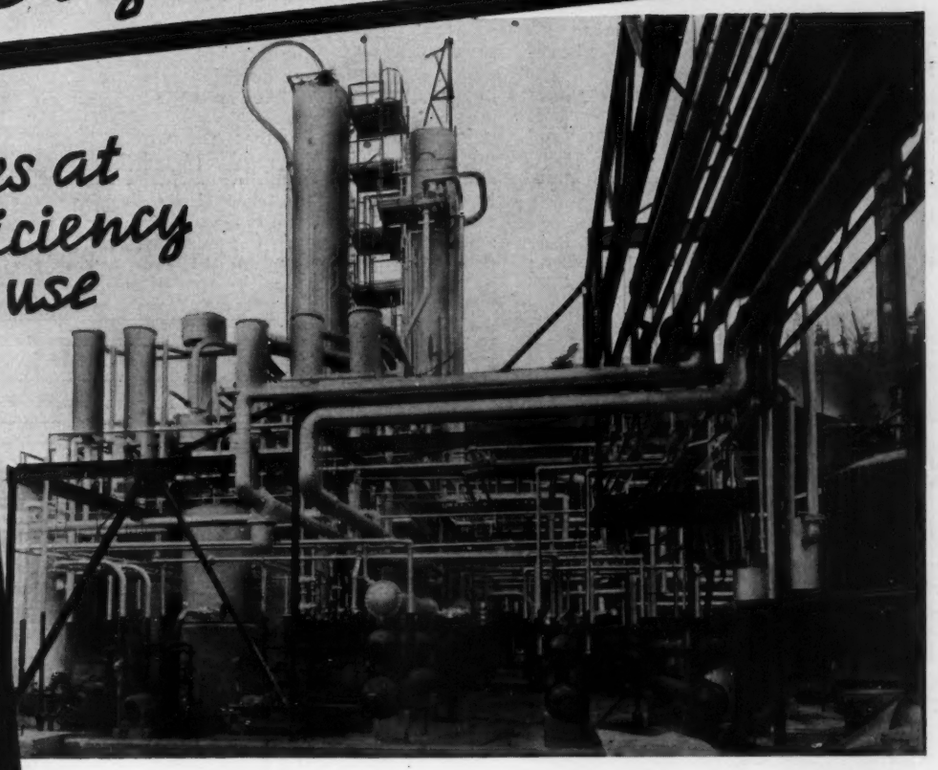
DOW Chemical Company has awarded contract to The Austin Company for a new plant to be constructed at Freeport, Texas. Work on the project, for which an 800-acre tract has been acquired will start late in April or early May. When completed, the plant will give employment to around 750 persons.

The company, through its subsidiary, Dowell Incorporated, furnishes a complete line of chemicals for petroleum refining, and supplies much of the ethylene bromide used by Ethyl Gasoline Corporation in the manufacture of anti-knock fluid.

Dow Chemical Company manufactures some 350 kinds of chemicals, including pharmaceutical in addition to industrial items. Its main plant is at Midland, Michigan, and additional plants are located at Marquette, Michigan; Venice, Pittsburg and Long Beach, California, and Wilmington North Carolina. Dowell Incorporated has a division office at Houston with S. C. Morian in charge as division engineer and C. T. Young as district manager.

Kentucky Refinery Built by Lummus—

now operates at highest efficiency through the use of B-H



Heat Insulation Products

To achieve peak operating efficiency for this 9000-barrel Atmospheric Vacuum Topping Unit, the most rigid specifications were laid down for its insulation. BALDWIN-HILL Insulation, applied by B-H applicators met every condition with B-H *high temperature and water resistant* Rockwool Blanket secured directly over the surface of the vessels. This was covered with ½" coat of B-H No. 1 Insulating Cement, weatherproofed with ¼" coat of B-H Weatherseal and finished with a coat of aluminum paint. There is a type of B-H Insulation to meet every condition of service. For any specific application or a problem that is out of the ordinary, call in a BALDWIN-HILL insulation engineer.

To obtain high insulating efficiency . . . low heat loss . . . outstanding durability — all at minimum cost, use the following products:

B-H ROCKWOOL BLANKET

B-H No. 1 INSULATING CEMENT

B-H No. 100 PIPE COVERING

B-H INSULATING BLOCK

B-H WEATHERSEAL

and other B-H insulating materials effective up to 2000° F.

Send for Catalog for complete data on entire line, applications, insulating efficiencies, heat loss charts, etc.

BALDWIN-HILL CO.

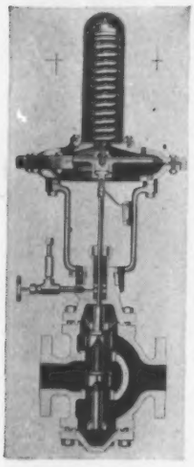
567 KLAGG AVE. . . . . TRENTON, N. J.

New Equipment for the Modern Plant

Stabilflo Valves
THE FOXBORO COMPANY

An improved line of "Stabilflo" controlled valves, designed for accurate response to demands of a control instrument without sacrifice of rugged construction, has been announced by The Foxboro Company, Foxboro, Massachusetts.

Equipped with a wide range V-port plunger, the valve has a rangeability of 50 to 1. When lifted off the seats, the initial clearance flow is 2 percent, and from 2 percent flow to 100 percent flow, the valve gives equal percentage increases in flow for equal amounts of valve lift. The V-port is screwed and pinned to the valve stem and designed for easy field reversal. In addition to this V-port valve plunger, a parabolic plug-type and a wide radio-turned plug-type are also available for exceptional control applications.



Foxboro Stabilflo Valve

Suspended construction of a floating-power motor eliminates need for guides and anti-friction bearings.

The motor, which may be removed without in any way disturbing the motor adjustments or the relation between valve and motor, is protected from accidental injury by a low center of gravity and rugged connection to the valve.

Excess friction is combatted in the one-piece bonnet and stuffing box assembly. The bonnet is joined to the valve body with a ground tongue and groove connection, assuring perfect alignment of the body and bonnet. Use of a deep lubricated stuffing box and polished stainless steel valve stem reduces stuffing box friction to a minimum.

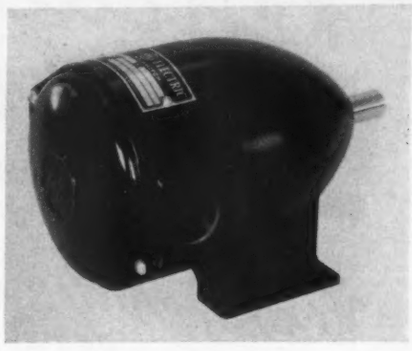
Plungers of the valves are provided with top and bottom guides of polished stainless steel. The guiding surfaces are large in both diameter and depth to provide freedom from excess wear. The spider construction of guide-supports prevents deposit of sediment that would otherwise interfere with operation of the valve.

Plugging Switch
GENERAL ELECTRIC COMPANY

Frictional parts and clutches are eliminated by use of an Alnico magnet in a new plugging switch for controlling motor stopping introduced by General Electric Company, Schnectady, New York.

In stopping a motor it is often desirable to reverse the power connection, and so bring the motor to rest quickly by its tendency to run in the reverse direction. This is plugging. However, if the motor is to stop, it is necessary that the plugging power be removed at the correct moment to keep the motor from re-accelerating in the reverse direction. This is accomplished by a plugging switch.

In the operation of the new switch, a driven Alnico rotor produces a rotating magnetic field which induces eddy currents in the walls of the aluminum cup. The magnetic reaction produced by the eddy currents turns the cup through its limited rotation, and the contacts are operated by the Textolite rod which connects the cup and the movable contact strip.



G-E Plugging Switch

Centering springs tend to keep the contacts in the normal position but since the magnetic operating force on the aluminum cup is dependent on speed, contacts operate at and above a definite speed. As the speed decreases, a definite point will be reached where the spring force will overcome the magnetic force. This is the tripping point. Changing the spring tension provides a simple means of adjusting the tripping speed over a definite range. A different tripping range can be obtained by changing the springs.

Phosphate Test
W. H. & L. D. BETZ

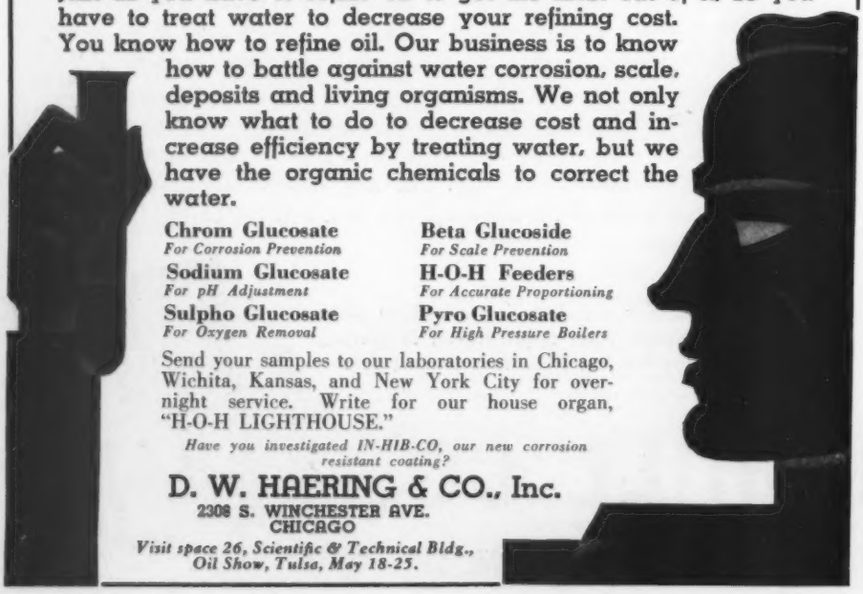
The Betz Junior Phosphate Comparator Set has been announced by W. H. and L. D. Betz, Philadelphia, as a means of testing boiler water for excess soluble phosphate. An adaptation of the colorimetric method of determining soluble phosphate, the set has been designed for use where time or personnel limitations make more elaborate methods impractical. A determination can be made in from 3 to 5 minutes.

The set consists of a wooden cabinet, removable comparator block with two permanent (maximum and minimum) color standards, two graduated mixing tubes with rubber stoppers, two grad-

Betz Junior Phosphate Comparator Set

YOU KNOW OIL—WE KNOW WATER

Just as you have to refine oil to get the most out of it, so you have to treat water to decrease your refining cost. You know how to refine oil. Our business is to know how to battle against water corrosion, scale, deposits and living organisms. We not only know what to do to decrease cost and increase efficiency by treating water, but we have the organic chemicals to correct the water.



Chrom Glucosate — *For Corrosion Prevention*
Beta Glucoside — *For Scale Prevention*
Sodium Glucosate — *For pH Adjustment*
H-O-H Feeders — *For Accurate Proportioning*
Sulpho Glucosate — *For Oxygen Removal*
Pyro Glucosate — *For High Pressure Boilers*

Send your samples to our laboratories in Chicago, Wichita, Kansas, and New York City for overnight service. Write for our house organ, "H-O-H LIGHTHOUSE."

Have you investigated IN-HIB-CO, our new corrosion resistant coating?

D. W. HAERING & CO., Inc.
2308 S. WINCHESTER AVE.
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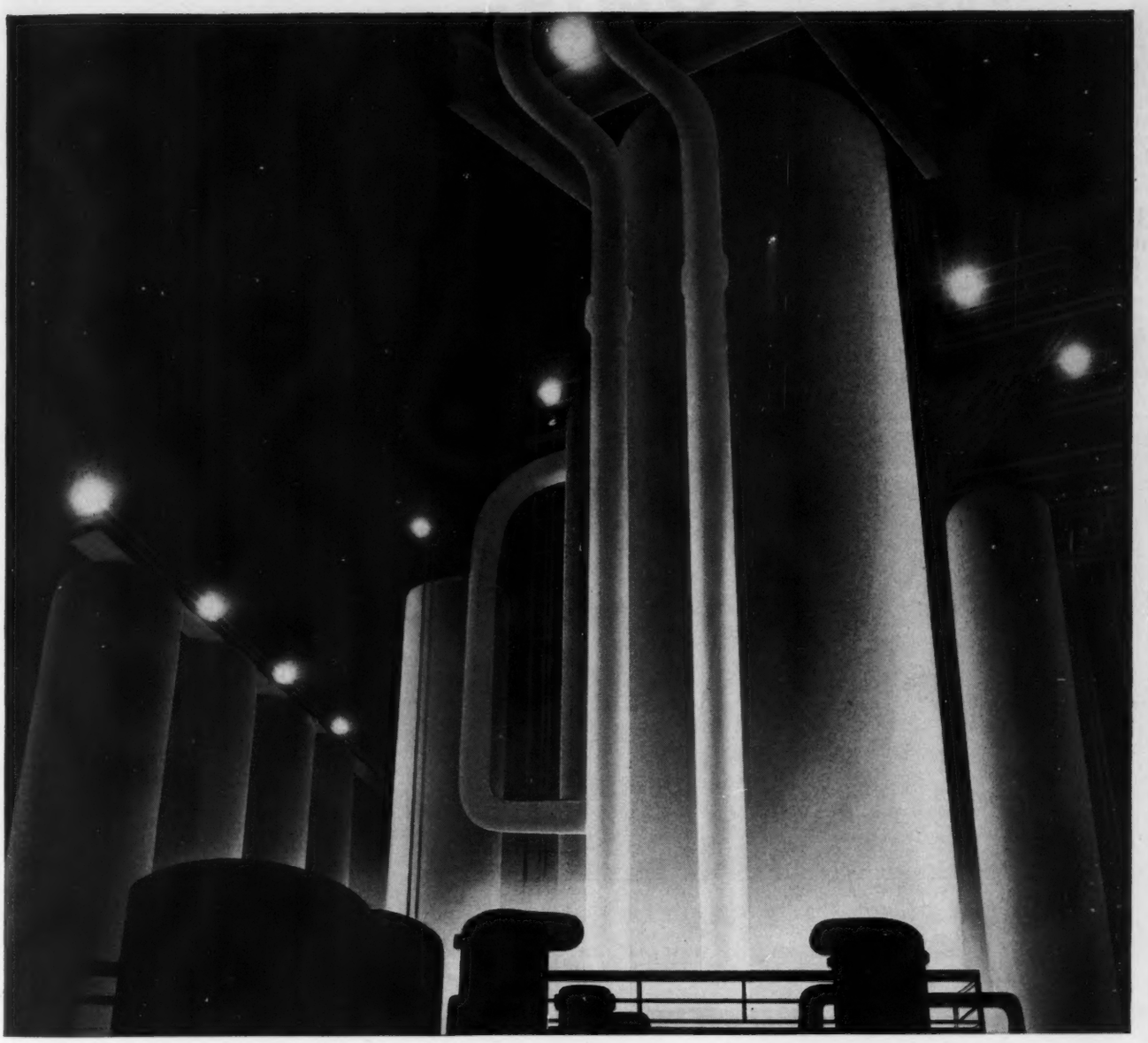
Visit space 26, Scientific & Technical Bldg., Oil Show, Tulsa, May 18-25.



HIGH STRENGTH FOR LOW TEMPERATURES

The fact that certain refinery equipment must work at sub-zero temperatures calls for care in selecting the steels that go into it. But that need not unduly complicate the problem.

The principal requisite, as distinguished from ordinary service, is that of good impact properties at low temperatures. Both laboratory tests and actual practical experience prove that Molybdenum steels in the SAE series have them.

It is for this reason that a valve manufacturer has standardized on SAE 4140 for valve fittings. Impact specifications in this case are on the basis of a temperature of minus 150° F., but the steel meets them consistently and effectively.

Data concerning the low temperature impact properties of this and other SAE Molybdenum steels are given in our technical book "Molybdenum in Steel", a copy of which will be sent free on request.

PRODUCERS OF MOLYBDENUM BRIQUETTES, FERRO-MOLYBDENUM, AND CALCIUM MOLYBDATE

Climax Mo-lyb-den-um Company
500 Fifth Avenue · New York City

MOLY

uated test tubes, one 20-cubic centimeter vial and graduated pipette, one extra graduated pipette and nipple, one 2-inch funnel with long stem, one box filter paper, one 16-ounce bottle molybdate reagent, one 1-ounce bottle of concentrated stannous chloride and complete instructions. Weight of the set is 5 pounds.

Electric Solderer

IDEAL COMMUTATOR DRESSER COMPANY

A new electric solderer has been announced by Ideal Commutator Dresser Company, 1531 Park Avenue, Sycamore, Illionis.

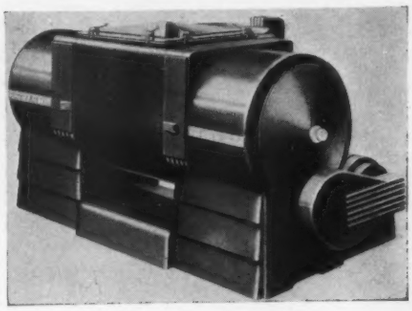
Called "Instant Heat" because it heats instantly upon touching the wire or terminal to be soldered, the tool is ideal for all kinds of light soldering. Hardly larger than a lead pencil, it easily reaches and solders in hard-to-get-at places. Heating stops instantly upon taking the carbons away from the wire or terminal, so that as soon as the soldering is finished the tool can be put away in the kit ready for the next job. It can also be laid down without fear of scorching article it touches.

The line current is reduced by a trasformer to harmless low voltage so there is no danger from electrical shock or burns. When soldering, heat is concentrated on exact part being soldered which eliminates danger of damaging adjacent delicate parts. Current is used only when in actual contact with work.

Mixing Machinery

THE PATTERSON FOUNDRY AND MACHINE COMPANY

A new line of Kneadermaster mixing, kneading and processing machinery has been introduced by The Patterson Foundry & Machine Company, East Liverpool, Ohio. The equipment is described as suitable for processing tenacious materials of every description.



Patterson Kneadermaster

Sizes are available in capacities up to 1,500 gallons, in 60 different combinations of frames, sizes and horsepowers. Experimental units are available from 1/3-gallon, and in a variety of types and strengths for medium and heavy-duty operations.

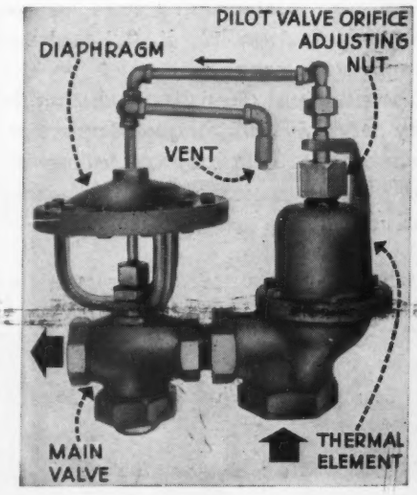
Air Eliminator

ARMSTRONG MACHINE WORKS

An automatic valve, designed for removal of air from steam-heated retorts, creosoting cylinders and on-and-off steam mains, has been announced by Armstrong Machine Works, 852 Maple Street, Three Rivers, Michigan.

The unit consists of a conventional-type diaphragm valve to which has been added a dome-shaped inlet chamber. Housed in the dome of the inlet chamber is a bellows-type thermal expansion unit that raises and lowers a needle valve seated against an orifice mounted in the top of the dome. The valve acts as a pilot to admit pressure to the top of the diaphragm. The other pipe above the diaphragm is fitted with a small relief vent to dissipate the pressure above the diaphragm when the pilot valve is closed.

Operation is based on the fact that air in a steam system has the effect



Armstrong Air Eliminator

Recent Sales!

17 TROY-ENGBERG STEAM ENGINES
for driving pumps and compressors in oil refineries

One of these seventeen engines was a Duplex unit developing 82 H.P. purchased to give the following special advantages in driving a large compressor: even torque, no dead center, high speed and small floor space for the horsepower.

Troy-Engberg Steam Engines fit well into the oil refinery picture. For many installations, they do so better than any other type of drive. For example, their dependability cannot be challenged; nor their flexibility and wide speed range; nor their economy. The fact that oil refineries in all parts of the world are specifying these engines is indicative of their utility.

TROY ENGINE AND MACHINE CO.
Established 1870 961 Railroad Ave., TROY, PA.

100% WESTINGHOUSE

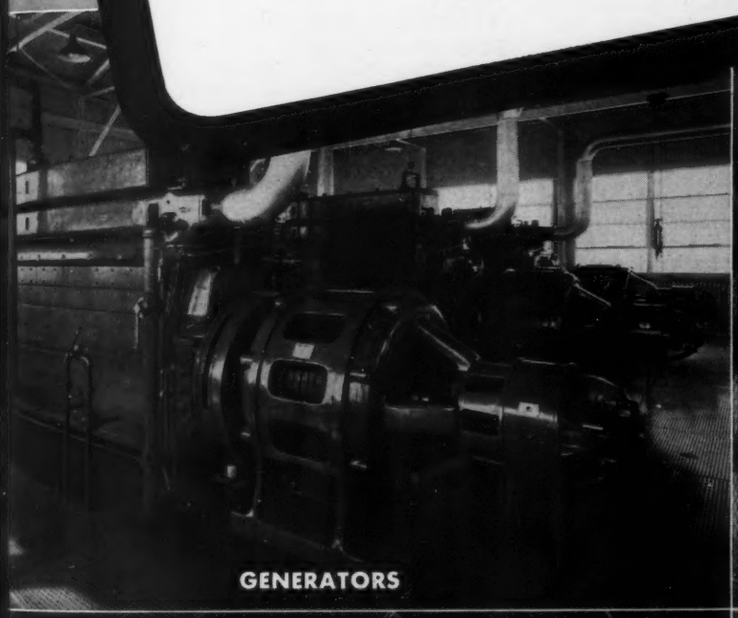
FOR COASTAL RECYCLING CORPORATION

Selection of Westinghouse as the supplier of all electrical equipment for Coastal Recycling Corporation's new plant at Agua Dulce, Texas, was based not only on quality of the equipment itself, but also on the ability of Westinghouse to coordinate electrical apparatus with the job to be done. Sizes and characteristics of generators, switchboard, motors and other auxiliary equipment were developed through the joint engineering efforts of the owners, the engineers and contractors, (Stearns-Roger Manufacturing Company), the other suppliers and Westinghouse.

For Westinghouse, such a working partnership is an everyday affair, whether it involves a complete installation such as this, or merely the selection of one piece of equipment to do a given job. And—this service is available quickly through our local offices in all important petroleum centers.

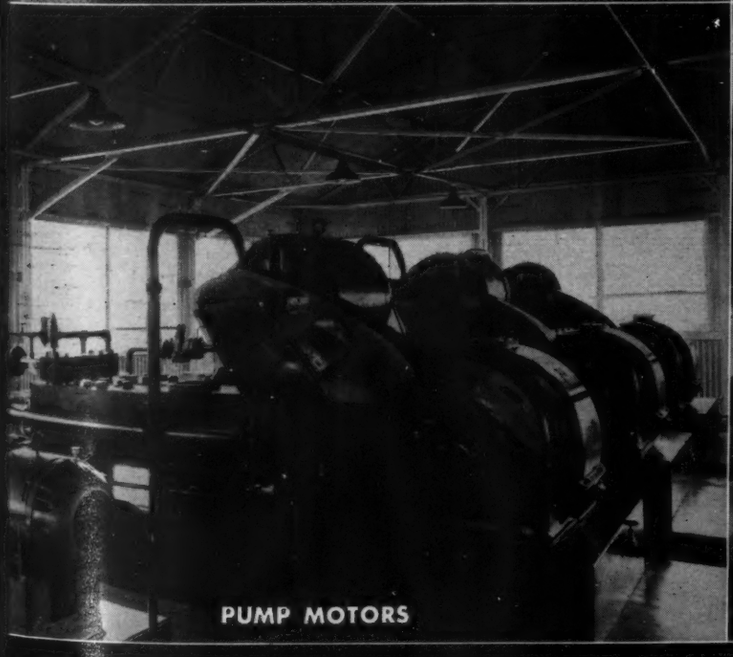
Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.

J-94258

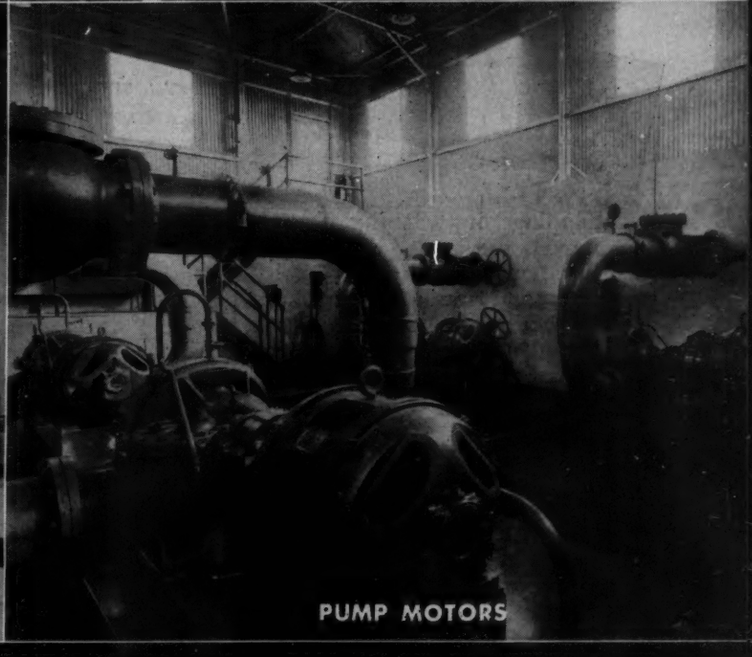


GENERATORS

SWITCHBOARD



PUMP MOTORS



PUMP MOTORS

Westinghouse

WESTINGHOUSE ELECTRIC

ELECTRICAL PARTNER OF THE PETROLEUM INDUSTRY

Another OAKITE IDEA to help you save!

YOU CAN STRIP PAINT SAFELY THIS EASY WAY

ARE YOU planning to strip your storage tanks this Spring before repainting? Want an easy, low-cost way to do the job safely, without fire or explosion hazards . . . without tedious, time-consuming scraping or chipping?

Then investigate the Oakite Hot Flow-on Method. Paint is completely, speedily removed right down to bare metal. Surfaces are left in excellent condition for repainting. And . . . since water solutions are used, there are no fire or explosion hazards. The low cost, too, will surprise you . . . only a few cents per square foot!

Save Money . . . Save Time ON THESE JOBS, TOO!

In stripping or washing drums, cleaning Diesel cooling systems or cleaning heat exchangers, Oakite materials and methods can help you improve results and reduce costs. Let us send you, without obligation, money-saving data on all your cleaning problems. Write today.

Manufactured only by

OAKITE PRODUCTS, INC.
50B Thames St., New York, N. Y.

Representatives in all Principal Cities of the U. S. and Canada

OAKITE Certified cleaning
MATERIALS & METHODS FOR EVERY CLEANING REQUIREMENT

of lowering the steam pressure, and hence its temperature. A mixture of air and steam entering the 2-inch inlet cools the thermal unit, which contracts and opens the needle valve. This, in turn, applies pressure to the diaphragm, depressing it and opening the main valve to permit the steam-air mixture to escape through a 1-1/4-inch outlet. When the air has been exhausted, pure steam envelopes the thermal element, causing it to expand and close the needle valve. With pressure relieved above the diaphragm, internal pressure forces the main valve to close.

Sensitivity of the air eliminator may be adjusted by means of a needle-valve regulating nut. By this adjustment, it will open just a fraction of a degree below steam temperature, or several degrees below, as may be desirable for the particular service.

The unit is described as self-compensating for changes in steam pressure. It measures 12½ inches in height, and weighs 30 pounds. Valve bodies are made of bronze.

Turbo-Compressor

YORK ICE MACHINERY CORPORATION

Announcement of the York-Allis Chalmers turbo-compressor for refrigeration and air conditioning installations has been made by York Ice Machinery Corporation, York, Pennsylvania. The unit is described as particularly suitable for steam-drive, but it can be powered by electricity.

Trichloromonofluoromethane, or Freon-11, is used as the refrigerant. The compressor is described as smooth and vibrationless in operation, permitting mounting of the assembly on upper floors or on light simple foundations.

Features include impellers operating at low speed, balance disc compensation of impeller thrust and bladeless diffuser passages for reducing pumping limit and increasing efficiency.

Condensers are of non-ferrous internal construction. The water cooler is of flash-type, non-ferrous construction with hermetically-sealed liquid pumps.

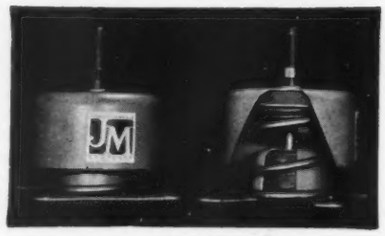
Control systems vary with the type of prime mover employed. Direct-drive, steam-turbine powered compressors are equipped with governors for speed regulating. Secondary control of variable speed motors, driving through speed-increasing gears, permits similar flexibility when electricity is employed. Safety devices are provided to assure the constant flow of chilled water, and to prevent freezing.

The turbo-compressors were developed through the combined efforts of the engineering organizations of York Ice Machinery Corporation and Allis-Chalmers Manufacturing Company.

Vibration Isolator

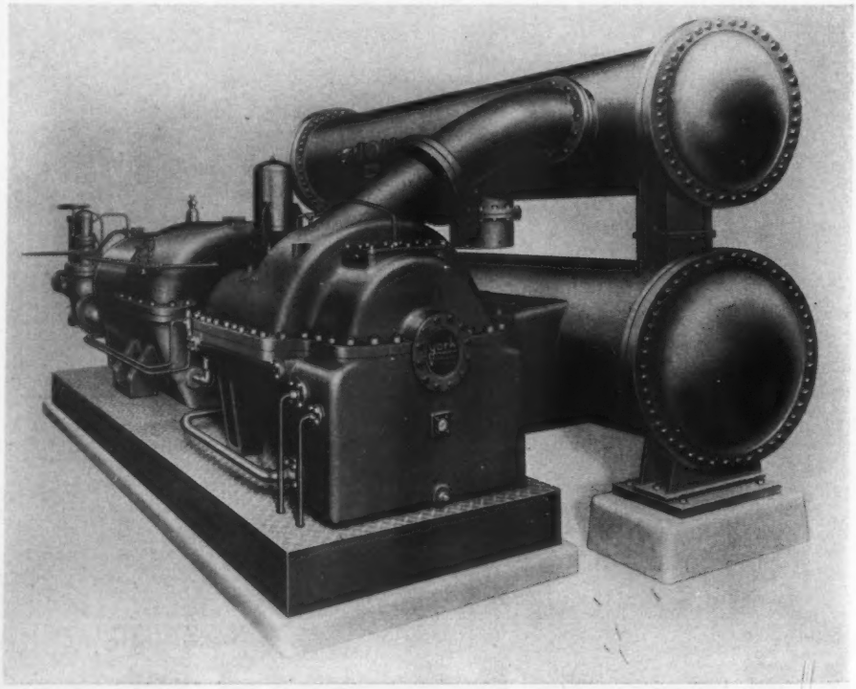
JOHNS-MANVILLE

A new vibration isolator designed for use on the bases of motors, generators, pumps, ventilating fans and similar equipment where vibration and excessive motion create noise and tend to wear out machine parts and damage connections, has been announced by Johns-Manville, 22 East 40 Street, New York.



Johns-Manville Isolator

The unit consists of a coil spring and rubber load pad that support the equipment to isolate vibration, and an



York-Allis Chalmers Turbo-Compressor

"A.W." Quality PRODUCTS

from Mine to Consumer

"SWEDE" PIG IRON
Foundry, Malleable and Basic Grades.

INGOTS
Standard and special sizes furnished in any Open Hearth analysis.

BLOOMS, BILLETS & SLABS
Alloy, Forging and Rerolling qualities.

SHEARED STEEL PLATES
Special Alloy, Tank, Ship, Boiler, Flange, Firebox, Locomotive Firebox, Structural and Dredge Pipe qualities.

HOT ROLLED SHEETS
All qualities, special Alloy, Annealed, Blued Finish, Hard Red, Pickled, or deoxidized to meet your needs.

FLOOR PLATES
For every kind of flooring condition: "A.W." Super Diamond, Standard Diamond, Diamondette, Sunken Diamond and Ribbed Patterns. Any pattern furnished in ferrous or non-ferrous analysis.

CUT STEEL NAILS
"Reading" Brand—all types and sizes or any special types produced.

FOR Carbon, Copper or Alloy Steels—in *any* Open Hearth analysis, in *any* quantity—ALAN WOOD can meet your specifications.

Do you want to reduce dead weight in mobile equipment, as well as stationary structures? "A.W." DYN-EL has been designed for this purpose. It has corrosion resistance better than ordinary Steel, excellent welding qualities with good forming qualities.

Do you need welding qualities, toughness, abrasion resistance, exceptional ductility or any other special qualities? There is an "A.W." Steel made to ALAN WOOD standards that will give you best results at the lowest possible cost.

The Metallurgical Department is the customer's representative in the ALAN WOOD plant—prescribing the purchaser's requirements in terms of Steel plant practice; inspecting and testing the finished product to insure compliance with purchaser's specifications.

"A.W." service includes cooperation of its entire organization to insure prompt execution of special mill orders.

ALAN WOOD STEEL COMPANY

MAIN OFFICE AND MILLS, CONSHOHOCKEN, PENNA. : : SINCE 1826 : : DISTRICT OFFICES AND REPRESENTATIVES—Philadelphia, New York, Boston, Atlanta, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, New Orleans, St. Paul, Pittsburgh, Roanoke, Sanford, N.C., St. Louis, Los Angeles, San Francisco, Seattle, Montreal—A. C. Leslie & Co. PRODUCTS INCLUDE—Steel Products in Carbon, Copper or Alloy Analyses : : Sheared Steel Plates : : Hot Rolled Sheets and Strip : : "A.W." Rolled Steel Floor Plates : : Billets, Blooms and Slabs : : "Swede" Pig Iron : : Reading Cut Nails.

adjustable rubber snubber inside the base to control excessive motion. It is designed to handle horizontal and torsional as well as vertical vibration.

The isolator is made in two sizes, light duty for loads from 60 to 190 pounds per isolator and heavy duty for loads from 250 to 720 pounds per isolator. Heavy machines may be equipped by clusters of the units. The loaded overall dimensions of the isolator are 6x6 inches by approximately 3-3/4 inches high. It is enclosed in a metal jacket to protect the rubber parts from oil and light.

Switchgear

GENERAL ELECTRIC COMPANY

Design improvements coincident with price reductions on Model MI-9 metal-clad switchgear have been announced by General Electric Company, Schenectady, New York.

All buses and connections are now completely insulated. The main bus is covered with a molded insulation having a dielectric strength in excess of the 5000-volt rating of the equipment, and all bus connections are covered with two-piece molded covers filled with compound. As in previous models, silver-to-silver, high-pressure contacts minimize oxidation of contact surfaces.

A screw-jack mechanism built into the housing raises and lowers the breaker. It can be manually- or electrically-operated. Mechanical interlocks, removable breakers, and isolated current transformers, buses and connections are also retained as features.

This unit uses a G-E circuit breaker employing the oil blast principal of circuit interruption. The primary disconnecting devices are of the stud-and-socket type, with silver-to-silver, high-pressure line contacts. Stationary sockets are mounted in glazed, wet-process porcelain; movable contacts are the oil-circuit-breaker studs. Secondary disconnecting devices automatically connect or disconnect all the secondary connections when the breaker is raised or lowered in the housing. Making and breaking the circuit is always done by the breaker, as mechanical interlocks prevent disconnecting or reconnecting the breaker while it is closed.

G-E Metal-Clad Switchgear

The breaker can be lowered by the built-in screw-jack mechanism onto a transfer truck and moved to a rack for inspection. Service interruptions during inspections are thus limited to the interval necessary to remove one breaker and replace it with another. An accessory inspection rack provides accessibility for servicing.

The switchgear is available for protection of circuits up to 5000 volts and 50,000 kva.

Diesel Engine

INTERNATIONAL HARVESTER COMPANY

A new 6-cylinder Diesel power unit that develops 100 horsepower at 1400 r.p.m., has just been announced by the

International 100 Horsepower Diesel

Let us help you

EXCEL IN 1940

You can do it with

LUBRICATING GAS-O-LINE
(REG. TRADE MARK)
ADMIXTURE
(Halogenated Aromatics)

while others are making "Guinea Pigs" of their customers and losses for their company.

WHY RISK SUBSTITUTES WHEN THE GENUINE COSTS SO LITTLE

"QUALITY" IS CHEAPER AT ANY PRICE

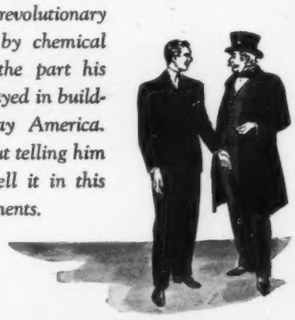
Our admixture will do the job right and avoid the danger and hazards of experimenting with your customers until you find something better.

Write today with information on what your requirements may be.

LUBRICATING GASOLINE COMPANY
P. O. BOX 820 HOUSTON, TEXAS

10,000 HORSELESS CARRIAGES A DAY

Suppose someone who lived forty or fifty years ago—say one of the founders of Mathieson—could pay us a visit today. And suppose we could have the pleasure of showing him the sights of 1940, of explaining the vast changes that have taken place since the turn of the century. What do you think would amaze the old gentleman most? If he were one of the pioneers who founded Mathieson, we believe he would be most interested in the revolutionary changes wrought by chemical progress and in the part his successors have played in building the present-day America. We would go about telling him the story as we tell it in this series of advertisements.



● Yes, Mr. M.—the modern world is using over forty million motor vehicles, and a new generation has grown up who never heard the old jeer, "Get a horse!" New highways criss-cross the continent, dotted with fleets of motor-trucks, motor-buses and a multitude of family cars.

Your successors at Mathieson, Mr. M., have had their share in promoting the growth of the great automotive industry which has "put the world on wheels". For Mathieson Chemicals enter into the manufacture or processing of nearly everything about the modern motor vehicle—glass, upholstery, tires, lacquer finish, plastic and metal parts, high test gasoline, oil and grease—even lamp filaments in headlights and anti-freeze in the radiator!

Constantly pioneering—constantly improving production and distribution methods to achieve new standards of quality and economies in raw materials—Mathieson has made basic contributions to the development of this and other great American industries.

MATHIESON CHEMICALS

SODA ASH . . . CAUSTIC SODA . . . BICARBONATE OF SODA . . . LIQUID CHLORINE . . . BLEACHING POWDER . . . HTH PRODUCTS . . . AMMONIA, ANHYDROUS and AQUA . . . FUSED ALKALI PRODUCTS . . . SYNTHETIC SALT CAKE . . . DRY ICE . . . CARBONIC GAS . . . ANALYTICAL SODIUM CHLORITE

THE MATHIESON ALKALI WORKS (INC.)
60 E. 42ND STREET, NEW YORK, N. Y.

NOW!

HIGH TEMPERATURE SWING JOINTS BY CHIKSAN

•

FOR TEMPERATURES TO 700° F.

•

FOR PRESSURES TO 500 POUNDS

•

6 STYLES

Style No. 60. 2-Way Swivel . . . Made in steel. also available in special alloys on order.

NO TIGHTENING OR ADJUSTMENT REQUIRED

This Joint does not depend for its rigidity upon bolted flanges, threaded parts, locking rings or keys of any type. All pressure is transmitted through double rows of hardened steel balls in flame-hardened races. The specially designed Packing Set is not affected by chemicals which are injurious to rubber or synthetic compounds. Many other features assure long life and dependable performance.

Representatives in Principal Cities. Distributed Nationally by Crane Co.

CHIKSAN BALL BEARING SWING JOINTS

CHIKSAN TOOL COMPANY

BREA, CALIFORNIA

International Harvester Company, 180 North Michigan Avenue, Chicago.

The engine, designated model UD-18, starts on gasoline and, after a minute or less of operation shifts to full Diesel operation. It can be cranked by hand. A standard 12-volt electric starting system may also be utilized to provide electric starting.

The unit is of compact construction and is provided with heavy, large-diameter flywheel. It has ample weight, approximately 3875 pounds less fuel, oil and water, and reserve strength for heavy-duty service. Cylinders are individually replaceable and are specially heat-treated. Cylinder bore and stroke are, respectively, 4¾ and 6½ inches. Piston displacement in 691 cubic inches, regular full-load governor speed 1400 r.p.m., and maximum torque 430 pounds-feet at 800 r.p.m.

The 7-bearing crankshaft is an alloy-steel drop forging. All bearings are replaceable and are diamond-bored for accurate size and shape and long life. A thermostatically-controlled cooling system and pressure lubrication through drilled passages are provided for efficient and economical operation.

The clutch is of the heavy-duty overcenter type. It is 17 inches in diameter and has 312 square inches of friction facing area. It locks in or out of engagement. When clutch is disengaged, springs free a lightweight driven disk which is splined to the power take-off shaft. Clutch torque capacity is 1488 pounds-feet.

Gas Regulator

FISHER GOVERNOR COMPANY

An improved low-pressure gas service regulator with a safety relief valve built integral with the regulator has been announced by Fisher Governor Company, Marshalltown, Iowa. The arrangement is designed to reduce overall dimensions and simplify piping.

The relief valve is diaphragm actuated, spring controlled and normally factory set and sealed to relieve at one pound. The upper diaphragm chamber is arranged to vent through the relief valve outlet.

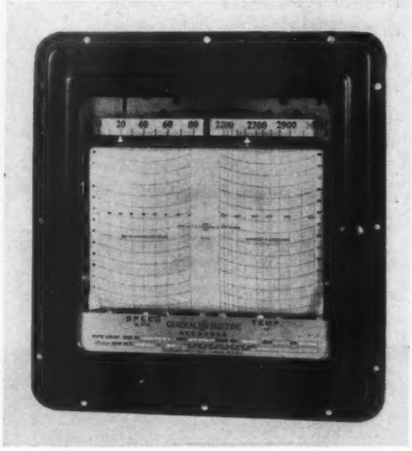
Working parts of the regulator are easily accessible without breaking pipe joints, valve bodies are interchangeable, and interior construction provides automatic loading, assisting the regulator in maintaing a constant reduced pressure even though flow demand may be high. Diaphragms are made of a non-porous composition impervious to gases.

The regulator is available in sizes ¾-inch, 1-inch and 1¼-inch, and is suitable for initial pressure up to 150 pounds and recommended for reduced pressure ranges of 2 to 10 inches of water column and 7 to 16 inches of water column.

Duplex Recorder

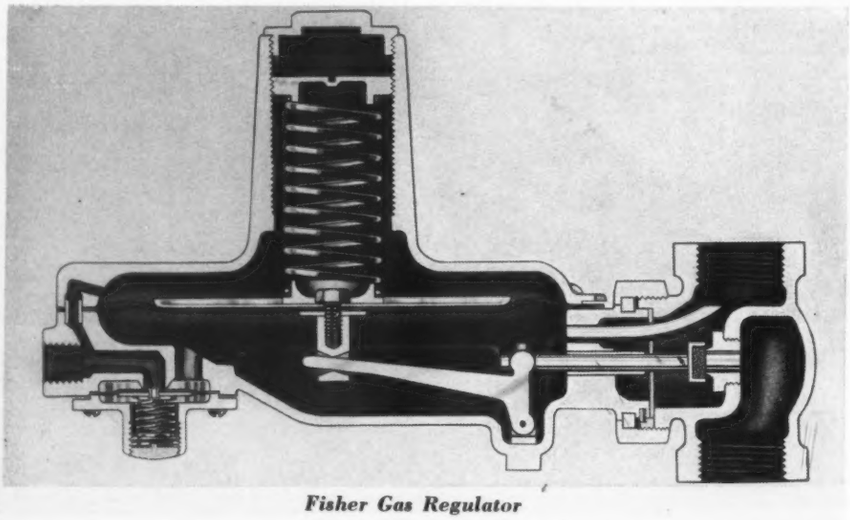
GENERAL ELECTRIC COMPANY

A new duplex recorder for recording simultaneously kilowatts and rkva, or kilowatts and frequency, or volts and amperes, has been announced by General Electric Company. It is expected to have a wide use wherever it is desirable to obtain synchronism between two separate records, or where space economy makes it necessary to place two separate recording mechanisms in a single case.



G-E Duplex Recorder

The duplex recorder consists essentially of two separate Type CD instruments placed side by side in one case and arranged to record on a single chart. Timed by a high-torque Telechron motor, or an 8-day spring clock, the chart carriage feeds the paper at 1, 2 or 3 inches per hour. Metal pins are provided on each end of the timing drum, engaging in holes on each side of the record paper, to assure a posi-

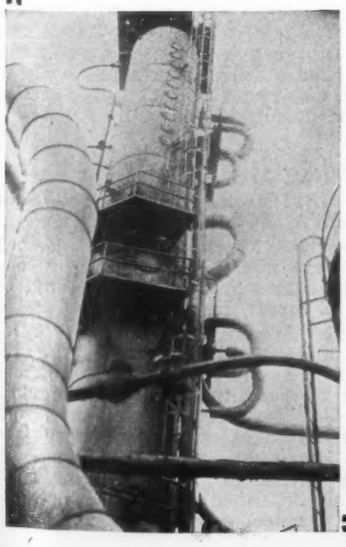


Fisher Gas Regulator

Specify ALLOY BUBBLE CAPS
by The PRESSED STEEL Company
on your next order

HERE'S WHY:

The fact that over 60% of the oil industry now use this type of bubble caps in fractionating equipment is evidence that they have decided advantages over the old style cast iron type. — They have been specified in the construction of practically all of the newer refineries. We can furnish a style of Bubble Cap that will fit your present construction requirements. — Send us your blue prints — no obligation, of course.



The Pressed Steel Company
WILKES-BARRÉ, PENNSYLVANIA

RISER NIPPLES ● SECTIONAL BUBBLE TRAYS ● WELDED
ALLOY TUBING TO MEET ANY SPECIFICATIONS

CORRECTION

The Mixing Equipment Company, Inc., calls attention to an obvious error in their two-page advertisement on gasoline blending appearing in the February issue of this magazine. **Wiggins Pontoon Roof tanks** were erroneously designated as "Balloon Roof" tanks. How many "eagle eyes" caught it? If you are one of those who did, write the Mixing Equipment Company and they will forward you a pocket slide rule since this is one on them.

MIXING EQUIPMENT COMPANY, INC.

1064 Garson Ave. Rochester, N. Y.

tive drive. Each element, equipped with a conventional pen and inkwell, is calibrated for a 4-inch ruled section of the 10-inch wide record roll. Instead of a single wide chart, a separate standard Type CD chart carriage and chart may be had for each element.

The two recording mechanisms are enclosed in a sheet-steel case for semi-flush switchboard mounting. Two lamps, one over each element, provide internal illumination. Connections are made on the back of the case.

Gas Mask

ACME PROTECTION EQUIPMENT COMPANY

The All-Purpose gas mask, introduced by Acme Protection Equipment Company, Pittsburgh, is designed for protection of industrial workers against fumes, smokes and mists.

The mask is described as providing full vision for the user, protection against carbon monoxide and other gases, a long effective life and a harmless chemical reaction that gives warning by odor as soon as protection against carbon monoxide commences to weaken. Avoidance of mechanical devices that may give trouble, and freedom from dials or indicators that may be hard to read, are described as advantages obtained by use of a warning agent.

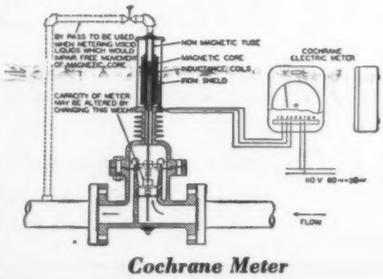
Meter

COCHRANE CORPORATION

A meter designed for measurement of fluids having characteristics of viscosity, corrosiveness and solubility, such as fuel oil, ammonia or hot tar, beyond the scope of the conventional orifice-type flow meter has been announced by Cochrane Corporation, 17 Street & Allegany Avenue, Philadelphia. It is called the Linameter.

The meter is of the area type, with meter body installed as an integral part of the pipe line, and containing a weighted disk positioned by the velocity of fluid through a tapered throat section in such a manner that the disk travel is proportional to flow rate. Attached to the weighted disk is a rod and iron core, the latter traversing the field of two reactance coils surrounding the pressure-tight tube of the meter body. The coils form a reactance bridge when connected electrically to similar coils in the indicating, recording and integrating instrument and form the means of transmitting the measurement a distance from the meter body.

The meter is made in different combinations of indicating, recording and integrating features to suit particular conditions, and may be equipped with pressure and temperature elements to record on the same chart with flow. Styles are available for wall, column or flush panel mounting.

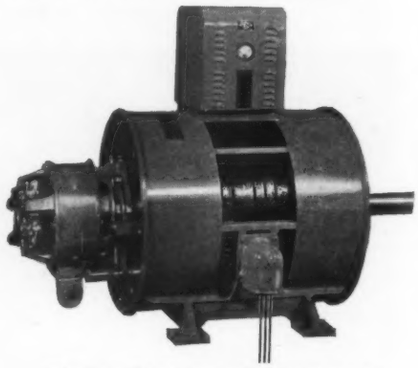


Cochrane Meter

Electric Motor

ELECTRIC MACHINERY MANUFACTURING COMPANY

A new synchronous motor of "packaged" construction has been announced by Electric Machinery Manufacturing Company, Minneapolis. The motor is wired in the same manner as a squirrel-cage induction motor, eliminating need for a separate panel-type control.



Electric Machinery's "Packaged" Synchronous Motor

The unit consists of a fabricated, all-steel motor of new design, a V-belt driven exciter mounted on top of the motor or direct-connected to the motor, and a field-control unit mounted on the motor for automatically applying and removing excitation for the field winding of the synchronous motor. The exciter and field-control unit are wired to the motor at the factory, leaving wiring between the synchronous motor and the line control unit, which may be wall-mounted across-the-line or compensator-type induction motor starter, to be done on the job.

The motors are available up to 350 hp at 1800 rpm.

Hose Coupling

THE INTERNATIONAL METAL HOSE COMPANY

A new re-attachable coupling for synthetic gasoline hose, designated "Uni-Flo," has been announced by The International Metal Hose Company, Cleveland.

The body and serrated tube of the coupling are a one-piece drop-forging of hard, dense, non-porous metal designed to withstand wrench abuse and rough usage. The coupling can be readily detached and re-attached, only a bench vice and a wrench being needed for the purpose.

Raschig Rings

THE UNITED STATES STONEWARE COMPANY

Porcelain Raschig rings of ¼-inch O. D. are now being offered by The United States Stoneware Company, 60 East 42 Street, New York.

Wall thickness of the rings is 1/16-inch, and about 85,000 rings are required per cubic foot. They present about 55 percent free space, offering, according to the manufacturer, about 212 square feet of absorption surface per cubic foot.

Commercial production of the small rings is described as being made possible by a new extrusion method.